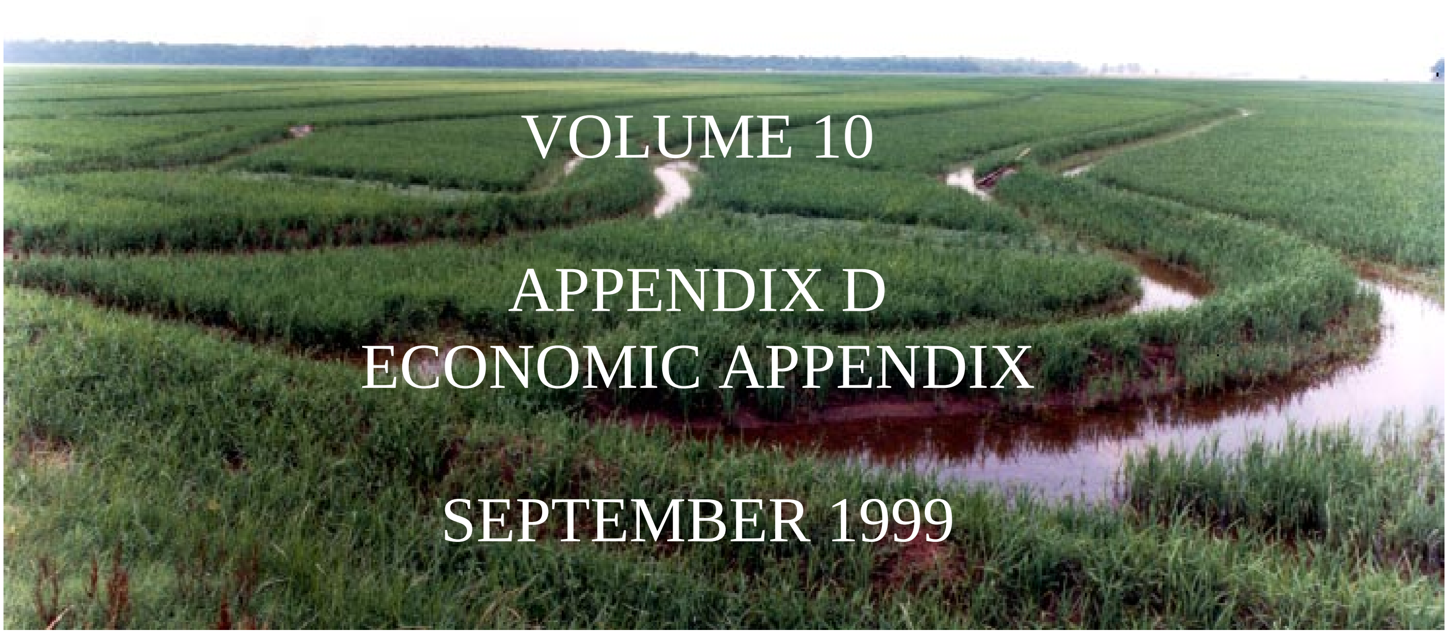
US Army Corps
of Engineers
Memphis District
Mississippi River Comission

EASTERN ARKANSAS REGION
COMPREHENSIVE STUDY

GRAND PRAIRIE REGION AND BAYOU METO BASIN, ARKANSAS PROJECT

GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

GENERAL REEVALUATION REPORT



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SEPTEMBER 1999

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APPENDIX D

ECONOMIC APPENDIX

SECTION I

OPTIMIZATION OF PROJECT FEATURES

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SECTION I - OPTIMIZATION OF PROJECT FEATURES

D-I-1. INTRODUCTION.

This appendix presents information pertaining to the optimization and economic evaluation of the features of the Grand Prairie Area Demonstration Project. The off-farm or import features of the project are presented in Section II while the on-farm features are presented in Section III. There are two significant differences in the underlying assumptions of Sections II and III. The first is a change in the project area's size at the request of the project sponsor. The second is a change in the implementation period (construction period) of the project.

a. Project Size. The on-farm features were optimized for a 267,000 irrigated acre area. Since these features were optimized, approximately 25,500 irrigated acres, or 10% of the area, was excluded from the project at the request of the project sponsor. The effect of this change is shown in Table D-I-1. A change in area served could change the optimization of some of the individual project features such as the pumping station and the main canal. However, the relative levels of features such as on-farm storage and conservation practices should remain unchanged since they were optimized based on a per acre or per farm basis. The absolute level of on-farm storage reservoirs and conservation measures will decrease as area served becomes smaller but their relative level will remain the same in that the average farm will still require the same level of these features. As the number of farms becomes smaller, the absolute levels of these features will also decrease proportionally.

When this change occurred only one import system size had been developed along with the array of on-farm plans. An In Progress Review (IPR) was held in December 1995 at the project sponsor's office in Stuttgart, Arkansas which was attended by the sponsor, the Lower Mississippi Valley Division, and the Memphis District. The findings of the studies to this point were presented at the IPR. There was a general agreement or "buy-off" that the optimum levels of the on-farm features had been identified and that these levels would be carried over into the optimization of the import system. The consensus of the IPR was for the Memphis District to document the optimization process for the on-farm features (which is presented in Section III) and move on to a optimization of the off-farm features (presented in Section II).

Table D-I-1

Comparision of Modified and Original Project Areas

Irrigation Water Used and Cleared Acres Subject to Irrigation

Grand Prairie Area Demonstration Project

Item	Modified Project Area			Original Project Area		
	Percent Dist.	Acres 1/	Water Used (ac-ft)	Percent Dist.	Acres 1/	Water Used (ac-ft)
Rice	36.3%	87,833	223,900	36.3%	97,076	250,300
Soybeans	33.6%	81,129	142,100	32.8%	87,706	155,300
Double-Crop	23.5%	56,909		23.6%	62,977	
Soybeans			77,500			86,700
Wheat			0			0
Grain Sorghum	3.0%	7,238	12,000	3.5%	9,310	15,500
Corn	2.2%	5,598	11,300	2.6%	7,110	14,600
Aquaculture	1.3%	3,070	14,400	1.2%	3,101	14,500
Total	100.0%	241,777	481,200	100.0%	267,280	536,900

1/ Cleared acres subject to irrigation.

b. Construction Schedule. The other significant difference between Sections II and III are the length of the construction period to implement a project. Section III uses a construction period of 13 years while Section II has a much shorter period of 7 years. There were two significant reasons for working to shorten the length of the construction period. A 13 year period would push completion of the project too far into the future allowing the aquifer to be depleted to an unacceptable level. A more detailed description of this problem is presented in the problems and needs paragraph below. The other reason was to provide the project sponsor with a completed project as quickly as possible so that the project financing and operation and maintenance costs could be recovered in a timely manner. If completion is pushed too far into the future, the sponsor would have to acquire a much larger burden of debt for project financing. Therefore, it was in the sponsor's best interests to minimize the total debt burden necessary to finance the project and concurrently lower its annual financing charges. It will also be much easier for the sponsor to recover its costs from the beneficiaries after they are receiving benefits instead of with promises of benefits in the future.

D-I-2. PROBLEMS AND NEEDS.

a. Problems. The project area is unable to meet its current and future agricultural water needs. Most of present needs are being met by a combination of surface and ground water. The shallow aquifer supplying ground water is being depleted faster than it can be recharged and water "mining" is occurring. Water mining has increased substantially over the past several decades. If this trend of mining continues the aquifer will be depleted and the area's economy which relies heavily on agriculture for its survival will begin to erode away in the very near future.

Many farms within the project area cannot meet all of an average year's water needs and as such only partially irrigate their crops. Some farms have started tapping a deep aquifer to supplement their water needs. However, the deep aquifer is only a stop-gap measure at best. The deep aquifer does not have the yield necessary to sustain long term irrigation and is very expensive to exploit. Farmers can only justify using the deep aquifer by "blending" these costs with their cheaper surface and shallow aquifer water costs. Irrigating with the deeper aquifer alone is not economically viable and as such cannot be viewed as a long term alternative.

b. Needs. There is a definite need for an alternative water source for the project area due to the depletion of the usable groundwater. If an alternative is not implemented, irrigation will be significantly reduced as ground water is no longer available. This occurrence will have a significant, adverse economic impact on the local economy. It will force many farmers, farm supply dealers, and lending institutions into bankruptcy along with others not directly related to agriculture, who's livelihood depends on the moneys provided by agriculture to the local economy.

D-I-3. PLANNING OBJECTIVES.

The primary objective of the proposed plans or projects is to provide an adequate and dependable source of agricultural water for users in the area. If this can be accomplished, groundwater depletions will be minimized or halted and the region can sustain and enhance its output of agricultural products and its economy. This objective can be accomplished in two manners. The first is to reduce the quantity of irrigation water used (demand) utilizing conservation measures which will increase the area's efficiency and minimize any current waste and losses. The second is to develop alternative sources of irrigation water. Examples of alternate sources are, but not limited to, an import system to bring water in from outside the area, deeper wells, and increased on-farm storage to catch rainfall during non-cropping seasons.

A secondary, although extremely important objective is to increase the amount of fisheries and wintertime waterfowl habitat. Currently, the area's farmers will pump its streams virtually dry during irrigation months. A project with an import system of canals and reservoirs would provide many acres habitat for fish and wildlife. Water routed through existing streams would flush stagnant pools from the streams in addition to preventing them from being pumped dry. The area's landowners also provide many acres of waterfowl habitat in the fall of the year. Waterfowl hunting has become a very lucrative practice that at times can produce more revenue per acre than farming. A significant portion of this acreage is flooded using groundwater. As groundwater is exhausted, this habitat will also decline. A project could also maintain or increase the area flooded for waterfowl.

A third objective or opportunity is prairie restoration. Prairie grasses could be established on the project's rights-of-ways and return portions of the area to its native vegetative state. This could possibly produce some savings to the project by reducing project maintenance costs. It is possible that mowing and spraying may not be required or desired on these areas if they are to be maintained as prairie habitat and that these costs could be saved.

D-I-4. POTENTIAL MEASURES MEETING OBJECTIVES.

There are several features or measures that can be incorporated into a plan of improvement that would help meet the objectives outlined above. They are:

a. Conservation Measures. Conservation measures cut water waste and losses by increasing the efficiency with which irrigation water is applied to the fields. Examples of measures that increase irrigation efficiency include land leveling, replacing open earthen canals with pipelines, installation of control structures, and tailwater recovery or recycling of irrigation water. Conservation measures effectively cut the demand for irrigation water and should be used as the first component of an alternative to the maximum extent practical or feasible unless alternative sources are more cost effective.

b. Import System. An import system would bring irrigation water into the area from outside sources. The only feasible source of import water that has been identified is the White River. The import system would use combinations of canals, pumping stations, pipelines, structures, and existing streams. It would supply water to fill existing and new on-farm storage reservoirs during non-crop season months for years that sufficient capture of rainfall is not available. During crop season months the import system would supply water directly to the fields with any surpluses going to refill reservoirs as necessary. Winter waterfowl acreage would be flooded after crop harvest with water supplied directly from the import system when flows are available in the White River.

Water supplied by the import system should be used before any of the remaining sources. The other sources should be saved and used when sufficient water is not available to meet all demands with the import system. Since the flows in the White River and the demand for irrigation water fluctuate significantly, there will almost always be times during each year when all demands cannot be met by the import system alone. If at the end of the crop season, a farmer sees that he has sufficient water remaining from his other sources to finish the crop year, he can stop using import water and make efficient use of his other sources.

c. On-Farm Storage. On-farm storage reservoirs consist of those already built and in use and new reservoirs built as part of the project. They are designed to catch and store excess rainfall for later use. If sufficient rainfall is not available, they can be filled with the import system. They are an integral part of any proposed project and should be used when sufficient water is not available to meet all needs with the import system. They should be used to meet the peak irrigation needs that exceed the capacity of the import system. They should also be used to make up for times when no water is available from the import system due to low flows in the White River.

d. Groundwater. It is anticipated that by the time a project with an import system could be built that most of the groundwater reserves will be exhausted and the aquifer depleted. Only the recharge rate would be available for irrigation. The recharge rate is the amount of water flowing into the aquifer each year. Groundwater should always be saved and used last only after the other features have been fully exploited. During years that there is a surplus of water from the other sources, groundwater should be saved and the aquifer allowed to recharge. In this sense, groundwater would be used like an on-farm storage reservoir that would save excess water from year to year to be used during times when water is not available from the other sources.

D-I-5. CONSTRAINTS ON POTENTIAL MEASURES.

a. Conservation Measures. Much of area has already had conservation measures applied to its irrigated acreage. The current problem obtaining irrigation water is so great that it has forced many farms to adopt practices that are considered marginal in areas with more abundant water sources. A significant number of farms are already at the leading edge of technology when employing conservation practices. Since so many of the best measures have already been installed, the potential for adding more is small and costly. However, the potential to add measures still exists on farms where the current problem has not become bad enough, where landowners have been either unwilling or unable to adopt new practices, or on small farms and farms with absentee owners.

b. Import System. The major constraint on the import system is the amount of water that could be provided by the White River. The flows in the White River fluctuate substantially throughout the year. It does not always have excess flows available for diversions. Further constraints are legal or institutional limitations on withdrawals from the river and the effects that withdrawals would have on competing users of the water, such as fisheries and aquatic habitat and current navigation users.

c. On-Farm Storage. The biggest constraint for building new reservoirs in the absence of an import system is that they cannot effectively be filled by rainfall capture. The area farmers have built a significant acreage of reservoirs and are catching all of the rainfall that can practically be caught during an average rainfall year. Most of the excess rain falls so fast that it cannot physically be caught and put into storage. The constraint on new storage with an import system is a farmer's unwillingness to give up productive cropland to build additional reservoirs. A point is reached when a farmer is better off putting his land into dryland farming instead of reservoirs.

d. Groundwater. There is the potential that the State of Arkansas could impose withdrawal restrictions within the area that could limit the amount of water provided by the aquifer. Any restrictions would probably extend the life of the aquifer but would immediately cause additional cropland to be converted to dryland practices and cause economic losses in the area. These tradeoffs would have to be carefully weighed before limitations are ordered. A further and more critical limitation is that if current trends continue the aquifer will be completely exhausted except for the annual recharge rate.

D-I-6. PLANS OF IMPROVEMENT.

The following is a complete listing of alternatives prepared for the Grand Prairie Demonstration Project. Some of the alternatives were carried forward through complete and detailed hydrologic, economic, and cost analyses. Others were screened or eliminated from detailed studies at various points throughout the planning process. Also each alternative developed was considered for the original project area consisting of approximately 267,300 irrigated acres and for the modified project area consisting of approximately 241,800 irrigated acres (Table D-I-1). The project area was modified or reduced approximately 11% at the request of the project sponsor as it refined its boundaries. Alternatives for the original project area are denoted with an A while the modified project area by B (example, Alternatives 1A and 1B). Several of the original project area's alternatives that contained an import system were analyzed with various withdrawal limitations on White River. The modified project area's alternatives were analyzed with the limitations of the current Arkansas state law on withdrawals from the White River.

a. Alternative 1. Alternative 1 is the no action alternative. It is the set of conditions expected to occur in the absence of a project. The supply of irrigation water is expected to decrease substantially as the area's groundwater resource is depleted. It is expected that only about 22% of the project area can be irrigated during an average year for future without-project conditions.

Alternative 1 was carried through detailed hydrologic and economic analyses and used as the base with which to compare the effects of all other alternatives. The hydrologic and economic analyses for Alternative 1 were conducted for the original and modified project areas and are presented in Sections II and III. They are defined as:

Alternative 1A for the original project area and
Alternative 1B for the modified project area

b. Alternative 2. Alternative 2 consists of building new storage reservoirs without conservation measures or an import system. The results of initial hydrologic modeling concluded that the area has already maximized on-farm storage reservoirs. Area farmers are already catching and storing the maximum amount of rainfall physically practical. Any further increases in the acreage of storage reservoirs would require alternative sources of irrigation water to effectively fill them. Building more reservoirs in the absence of an alternative source, the amount of irrigation water available to the farmers would actually decrease by spreading the limited water available over a larger surface area and increasing evaporation and infiltration losses. Since it is questionable whether the reservoirs could be filled without an import system and since this alternative does not meet the objectives of the study, it was not carried forward into detailed study.

c. Alternative 3. Alternative 3 consists of conservation measures, including a limited amount of additional on-farm reservoirs, with no import system. These measures are designed to increase the efficiency or usage of irrigation water, from 60 percent to 70 percent. Currently only 60 percent of the irrigation water brought to the fields is used by the crops. The other 40 percent is lost through waste, evaporation, and infiltration into the ground. These measures are designed to minimize losses, recycle or reuse water through tailwater recovery systems, and construction of on-farm storage reservoirs. Conservation measures could be placed on approximately 31 percent of the area's current irrigated acreage. When groundwater is depleted or regulated at the safe (recharge) yield only about 31 percent of the area could remain in irrigation in the absence of some form of supplemental source of irrigation water. The remainder of the area would convert to dryland agriculture. A detailed economic analysis for Alternative 3 was conducted for the original project area only. Alternative 3 for the two project areas is defined as:

Alternative 3A for the original project area and
Alternative 3B for the modified project area

d. Alternative 4. Alternative 4 includes conservation features (excluding on-farm storage reservoirs) described in Alternative 3 in conjunction with an 1,800 cfs import system which diverts irrigation water from the White River. It would use the import system to fill the area's existing on-farm reservoirs during non-crop seasons and provide water directly to the fields during crop seasons. However, consultation with NRCS revealed that the desired conservation efficiencies could not be achieved without building new reservoirs. This alternative was eliminated from detailed hydrologic and economic studies since all prior studies (the Feasibility Study, NRCS studies, and preliminary PED studies) have shown that conservation yields the most return per dollar invested. Since conservation is the most cost effective measure, it should always be the first component of any plan developed.

e. Alternative 5. Alternative 5 consists of a combination of the conservation measures in Alternative 3, on-farm storage reservoirs capable of providing approximately 25 percent of existing irrigation needs or 30 percent of with-project needs reduced by conservation measures, and an 1,800 cfs import system. The import system provides irrigation water from excess flows in the White River and feeding it to the farms through a network of new canals and existing streams. In most instances new canals would be dug along higher ground in the area so that the irrigation water could gravity feed to the fields, thus reducing on-farm pumping costs. These three components cannot be viewed as independent or stand-alone features. They are related and are dependent on each other to function properly. Analyses for Alternative 5 were also conducted for the original and modified project areas and designated as:

Alternative 5A for the original project area and
Alternative 5B for the modified project area

Alternative 5A requires 9.790 acres of additional on-farm storage supplying 97,900 acre-feet. Alternative 5B requires 8,849 additional acres supplying 88,493 acre-feet due to the reduction in the area served. Alternative 5A was further analyzed at various stop-pump constraints or withdrawal limitations on the White River to demonstrate that the most efficient level was identified. The constraints included the current Arkansas State Water Plan which is a variable rate and the following flows measured in cubic feet per minute (CFS): 5,250; 7,125; 9,650; 11,350; 12,850; and 17,500 CFS. These alternatives were named as:.

Alternative 5A(1) -- 5,250 CFS residual flow
Alternative 5A(2) -- 7,125 CFS residual flow
Alternative 5A(3) -- 9,650 CFS residual flow
Alternative 5A(4) -- 11,350 CFS residual flow
Alternative 5A(5) -- 12,850 CFS residual flow
Alternative 5A(6) -- Current Arkansas State Water Plan
Alternative 5A(7) -- 17,500 CFS residual flow

The results of investigations into Alternative 5A indicated that it was economically viable to withdraw excess flows down to the 5,250 to 7,125 cfs range. However, it was recognized that since current Arkansas state law limits the potential withdrawals, this institutional constraint should be used as the maximum withdrawal for comparing the effects of all alternatives. Alternative 5B was analyzed for (6) above, the Current Arkansas State Water Plan only in that its levels of both on- and off-farm features were carried into a later alternative, Alternative 7C.

f. Alternative 6. Alternative 6 consists of the conservation features and 1,800 cfs import system in Alternative 5 above. The difference is that the new on-farm storage reservoirs are increased an additional 25 percent. Alternative 6 for the original and modified project areas was designated as:

Alternative 6A for the original project area and

Alternative 6B for the modified project area

Alternative 6A requires 12,238 acres of additional on-farm storage supplying 122,380 acre-feet. Alternative 5B requires 11,061 additional acres supplying 110,610 acre-feet due to the reduction in the area served. A detailed hydrologic and economic analysis was conducted of Alternative 6A at the same withdrawal limitations on the White River as used for Alternative 5A. These resulting alternatives were designated as:.

Alternative 6A(1) -- 5,250 CFS residual flow
Alternative 6A(2) -- 7,125 CFS residual flow
Alternative 6A(3) -- 9,650 CFS residual flow
Alternative 6A(4) -- 11,350 CFS residual flow
Alternative 6A(5) -- 12,850 CFS residual flow
Alternative 6A(6) -- Current Arkansas State Water Plan
Alternative 6A(7) -- 17,500 CFS residual flow

A comparison of Alternatives 5A and 6A revealed that increased levels of on-farm storage was not economically feasible. Any increased benefit provided by additional storage levels was more than offset by the added cost of building the storage. Because of this, Alternative 6B was not carried into detailed hydrologic or economic studies.

g. Alternative 7. The prior alternatives were used to optimize the on-farm features of the project (conservation measures and on-farm storage reservoirs). All prior alternatives used an 1,800 CFS import system. This is the hydrologic optimum for satisfying an average year's demands for the original un-reduced area in conjunction unlimited withdrawals from the White River. However, the White River cannot support unlimited withdrawals due to low flows and the institutional constraint of current state law. Because of these constraints, it was necessary to look at an array of import system sizes to show that the optimum import system was chosen from an economic standpoint. The on-farm components of Alternative 7 were held constant at the optimum levels of 70 percent conservation and on-farm storage of 8,849 acres (88,490 acre-feet) which was identified from detailed analyses of Alternative 5A above. Only the import system is allowed to vary for Alternative 7. The following four alternatives were analyzed under the Current Arkansas State Water Plan. The 1,800 CFS system is the hydrologic optimum for the original project area as described above. The equivalent for the modified (reduced) project area is 1,640 CFS. Additionally, two others on each side of these two alternatives were studied to identify the NED alternative. The four alternatives are:

Alternative 7A -- 1,480 CFS import system
Alternative 7B -- 1,640 CFS import system
Alternative 7C -- 1,800 CFS import system
Alternative 7D -- 1,960 CFS import system

D-I-7. IMPORT SYSTEM OPTIMIZATION.

A summary of the results of the economic analysis of the import system is presented in Table D-I-2. This table shows benefit and cost data for the four alternatives in the modified project area. Alternative 7B, the 1,640 CFS import system is the optimum plan. It includes the optimum conservation level of 70% as established by NRCS, 8,849 acres of new on-farm reservoirs, and the Arkansas State law on withdrawal limitations from the White River. A detailed presentation of the optimization of the import system is presented in Section II of this appendix

D-I-8. OPTIMIZATION OF ON-FARM FEATURES AND WHITE RIVER WITHDRAWALS.

A summary of the results of these features is presented in Table D-I-3. This table shows benefit and cost data for the three alternatives in the original project area. Alternative 3A, the conservation only alternative, provides the best return per dollar invested with a benefit-to-cost ratio of 2.01 to 1. Since it provided the highest returns per dollar invested, it was used as the first feature of all alternatives. The optimum conservation level was established by NRCS as 70% efficiency. Alternatives 5A and 6A establish the optimum on-farm storage level. Alternative 5A is the optimum storage level at 9,790 acres of new on-farm reservoirs.

Seven levels of “stop-pump” or residual river flows in the White River are also presented for Alternatives 5A and 6A. As shown in the table, the more water that can be withdrawn from the White River, the better the returns. However, the institutional constraint of the Arkansas State law on withdrawals limits the amount of water that the project can provide. A detailed presentation of the optimization of these features and withdrawal limitations is presented in Section III of this appendix.

Table D-I-2

Summary of First Costs and Average Annual Equivalent Benefits, Costs, Excess Benefits, and Benefit to Cost Ratios

Grand Prairie Area Demonstration Project

(October 1996 Price Levels, 7.375% Discount Rate)

Item	Alternative 7A	Alternative 7B	Alternative 7C	Alternative 7D
	($)	($)	($)	($)
First Cost				
Import System	195,419,000	201,928,000	208,438,000	214,947,000
On-Farm	68,584,000	68,584,000	68,584,000	68,584,000
Total	264,003,000	270,512,000	277,022,000	283,531,000
Annual Benefits				
Irrigation Benefits	34,823,000	35,659,000	36,266,000	36,844,000
Waterfowl Benefits	467,000	473,000	478,000	487,000
Total	35,290,000	36,132,000	36,744,000	37,331,000
Annual Costs				
Interest				
On-Farm	6,325,000	6,325,000	6,325,000	6,325,000
Import System	16,893,000	17,456,000	18,019,000	18,582,000
Sinking Fund				
On-Farm	185,000	185,000	185,000	185,000
Import System	495,000	512,000	528,000	544,000
Operation and Maintenance				
On-Farm	910,000	910,000	910,000	910,000
Import System				
Pump Station	2,982,000	3,130,000	3,256,000	3,382,000
Small Pump Stations	340,000	348,000	354,000	359,000
Structures	207,000	209,000	211,000	212,000
Channels and Canals	42,000	42,000	42,000	42,000
Navigation Impacts	121,000	127,000	132,000	136,000
Induced Flooding	12,000	12,000	12,000	12,000
Total	28,512,000	29,256,000	29,974,000	30,689,000
Excess Benefits				
Irrigation Benefits Only	6,311,000	6,403,000	6,292,000	6,155,000
All Benefits	6,778,000	6,876,000	6,770,000	6,642,000
BCR				
Irrigation Benefits Only	1.2	1.2	1.2	1.2
All Benefits	1.2	1.2	1.2	1.2

Table D-I-3

Summary of First Costs and Average Annual Equivalent Benefits, Costs, Excess Benefits, and Benefit to Cost Ratios

Grand Prairie Area Demonstration Project

(October 1995 Price Levels, 7.75% Discount Rate, $000)

Alternative	Investment Cost	Annual Benefits	Annual Costs	Excess Benefits	Benefit to Cost Ratios
Alternative 3A	20,189	5,949	2,959	2,990	2.01
Alternative 5A(1)	315,579	66,448	47,361	19,087	1.40
Alternative 5A(2)	315,579	66,332	47,349	18,983	1.40
Alternative 5A(3)	315,579	64,760	47,209	17,551	1.37
Alternative 5A(4)	315,579	62,197	47,000	15,197	1.32
Alternative 5A(5)	315,579	58,838	46,630	12,208	1.26
Alternative 5A(6)	315,579	54,538	46,027	8,511	1.18
Alternative 5A(7)	315,579	49,213	45,552	3,661	1.08
Alternative 6A(1)	327,123	66,782	49,163	17,619	1.36
Alternative 6A(2)	327,123	66,679	49,151	17,528	1.36
Alternative 6A(3)	327,123	65,081	49,011	16,070	1.33
Alternative 6A(4)	327,123	62,576	48,806	13,770	1.28
Alternative 6A(5)	327,123	60,334	48,445	11,889	1.25
Alternative 6A(6)	327,123	54,764	47,849	6,915	1.14
Alternative 6A(7)	327,123	49,894	47,381	2,513	1.05

SECTION II

IMPORT SYSTEM OPTIMIZATION

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SECTION II - IMPORT SYSTEM OPTIMIZATION

D-II-1. INTRODUCTION.

This section of the Economic Appendix presents information concerning the optimization of the import system (pump station and canals portion) of the Grand Prairie Area Demonstration Project. It is based on supplying irrigation water to a 238,700 acres of cropland and 3,070 acres of fish ponds in Arkansas, Monroe, and Prairie counties in eastern Arkansas. This area is described in later paragraphs. The import features were optimized on a system-wide basis. The demands (water uses) of the individual farms were aggregated and modeled against historical White River flows to determine the supply which could be diverted by the different import system sizes and to assess the effects of potential with-project withdrawals on competing users.

D-II-2. GENERAL.

This section describes the methodology used to determine the benefits accruing to the project under existing and future conditions. The evaluation uses current (1996) agricultural land use and price levels. Current agricultural land use was based on a complete survey of the area conducted by the US Department of Agriculture, Natural Resources Conservation Service (NRCS). The survey was a compilation of the historical records maintained by each county's Farm Service Agency's office. It also required a projection of future with- and without-project conditions throughout the project life.

The price level of the benefits and costs is October 1996. The costs of individual construction items are assumed to be end of year values. The benefits associated with each item are assumed to occur 1 year after the item's cost. The reference point for calculating present values of benefits and costs is the beginning of 2008, the first year after project completion. All costs and benefits prior to 2008 are compounded forward and all costs and benefits after 2008 are discounted backward at a discount rate of 7.375 percent. The total present values are amortized over a 50 year project life to obtain average annual equivalent benefits and costs. The benefits accruing to each alternative are comprised of irrigations benefits and waterfowl benefits.

D-II-3. AREA DESCRIPTION.

The area that would benefit from project construction consists of approximately 363,000 acres located in Arkansas, Lonoke, Monroe, and Prairie Counties in Arkansas. The area is predominately agricultural with scattered rural development. A total of 248,000 acres is cleared, in agricultural production and subject to irrigation in any one year. Approximately 94 percent of the cropland in the area is irrigated during any one year. The remaining 6 percent of cropland not irrigated is usually due to farm programs or ongoing improvement operations such as land leveling. However, recent changes in farm programs and government subsidies will probably reduce the acreage idled during any one year. For this reason, the without- and with-project comparisons were conducted under the assumption that all of the area will be irrigated during an average year.

D-II-4. PLANS OF IMPROVEMENT.

The following is a presentation of the alternatives used in the optimization of the import system. All of these plans are designed to take advantage of all existing sources of irrigation water in addition to water that they can potentially supply. These existing sources include groundwater, on-farm storage reservoirs, rainfall capture, and tailwater recovery (recycling of irrigation water). They utilize the optimum levels of on-farm features identified in Section III of this appendix. The on-farm components are held constant at the optimum levels of 70 percent conservation and on-farm storage of 8,849 acres (88,490 acre-feet) which was identified from detailed analyses of Alternative 5A. Only the import system is varied. The following four alternatives were analyzed under the Current Arkansas State Water Plan. The 1,800 CFS system is the hydrologic optimum for the original project area. The equivalent for the modified (reduced) project area is 1,640 CFS. Additionally, two others on each side of these two alternatives were studied to identify the NED alternative. The four alternatives are:

Alternative 7A -- 1,480 CFS import system
Alternative 7B -- 1,640 CFS import system
Alternative 7C -- 1,800 CFS import system
Alternative 7D -- 1,960 CFS import system

D-II-5. WITHOUT-PROJECT CONDITIONS.

a. Present Conditions. The first step in defining present (1996) conditions was to determine existing land use. This was done in conjunction with the National Resource Conservation Service (NRCS). A GIS of the area's Farm Service Agency's records was developed consisting of data broken down to the farm tract level showing the acreage of individual crops on each tract. This data revealed that all of the tracts suitable for irrigation were currently subject to irrigation, either partially or fully. There are 241,777 acres subject to irrigation in the study area. This figure does not include 8,849 acres of single-cropped soybeans on which the planned on-farm storage reservoirs will be constructed. This omission was made in order to facilitate a direct comparison between without- and with-project conditions. Approximately 94% of this area is irrigated in any given year. The remainder is usually idled by farm programs or by the need to install land treatment measures such as land leveling or tailwater recovery measures. Soybeans account for 57.1% (81,129 acres single-cropped and 56,909 acres double-cropped with wheat) of the total. Rice follows at 36.3% (87,833 acres), grain sorghum at 3.0% (7,238 acres), corn at 2.2% (5,598 acres), and aquaculture at 1.3% (3,070 acres).

Agriculture uses approximately 481,200 acre-feet of irrigation water during an average year. Rice is the heaviest user at 46.5% or 223,900 acre-feet. Soybeans follow closely at 45.6% or

219,600 acre-feet. All other uses amount to only 47,700 acre-feet or 7.9%. The majority of the water used in the area comes from the area's alluvial aquifer. Groundwater accounts for 84.8% or 408,007 acre-feet of total use. The remaining 15.2% or 73,188 acre-feet come from on-farm storage reservoirs which are filled during non-crop seasons and tailwater recovery systems which reuse or recycle either in-season rain or irrigation water which has been drained from the fields.

NRCS combined the above data with the crop's daily water requirements, in-season rainfall data, and evaporation/transpiration data to conduct a water balance analysis for the period of 1965-82. The result of the analysis was an average ten day water requirement, unmet by rainfall, for each year of the period of record. Ten day periods were used since this time period corresponds to the wilting point of the crops, the point at which yield reductions occur unless supplemental water is applied. The resulting demand is the demand for water that must come from other sources such as groundwater or storage reservoirs (the demand unmet by rainfall). NRCS then compared the seasonal demand for irrigation water with the seasonal availability of rainfall, groundwater, water from storage reservoirs, and tailwater recovery to determine the amount of irrigation water supplied from each source and determine the volume of water that must come from outside sources as groundwater is depleted. A description of the water balance analysis is presented in the NRCS portion of this report. The 18 year period was subsequently expanded by the Memphis District utilizing a regression model to 1940-86 to yield a 47 year sample which was felt to be more reliable and representative of the area conditions. This period was used because the Little Rock District had an existing synthetic period of record for flows on the White River for this time span which could be used to determine the availability of irrigation water under with-project conditions.

The regression model correlated the demands developed by NRCS with rainfall, temperature, and evaporation/transpiration data for the years 1965-82 to extend the period used to estimate the demand for irrigation water. The resulting relationship was then applied to the remaining years to extend the period to 1940-86. The actual data developed by NRCS for the years 1965-82 was used in the analysis instead of the results of the regression model. The results of the regression model were used for the 1940-81 and 1983-86 periods. The resulting period of record for demand was input into a supply model developed by the Memphis District Hydraulics Branch in conjunction with HEC in Davis, California. A description of this model is presented in the Hydraulics Appendix. A comparison of the yearly demand and supply data revealed that in order to meet all demands, substantial amounts of groundwater were required which resulted in significant annual depletion of the alluvial aquifer.

The final step was to estimate the net value of the area's agricultural production. This was done by developing crop practices, budgets, and yields for the area from data supplied by NRCS, University of Arkansas Extension Service, and interviews with area farmers. All data was modified to reflect local conditions when necessary. This data was applied to the number of acres of irrigated cropland and fish ponds in the project area resulting in the value of the area's contribution to the national economy. Table D-II-1 contains the data compiled for this section.

b. Future Without-Project Conditions. Under future without-project conditions the desired land use and demand for irrigation water was the same as for present conditions. Irrigated cropland and fish ponds would remain at 241,777 acres and water use would remain at 481,200 acre-feet if sufficient irrigation water was available. The major difference between present and future conditions is the availability of groundwater. The supply of groundwater is expected to be significantly reduced as the aquifer is depleted. This is backed up by a University of Arkansas study for the Memphis District during the feasibility phase of this study and reaffirmed by field observations of current conditions by NRCS field personnel and local farmers. Since a significant amount of groundwater is expected to be lost, a significant acreage must shift to dryland farming practices, which results in substantially reduced agricultural production in the project area.

(1). Supply of Irrigation Water. Considerable uncertainty exists when trying to estimate the point at which the aquifer will become exhausted and its yield will be limited to its recharge rate. If a series of "wet" years occur with excessive rainfall, this point will be pushed farther into the future. If a series of "dry" years occur with minimal rainfall, this point could be swiftly accelerated. However, well before the aquifer is completely exhausted the State of Arkansas will probably declare this area a critical water shortage area. At this point the State will begin limiting withdrawals at levels close to the recharge rate to prevent permanent damage of the aquifer. Therefore, the recharge rate will probably become the limiting groundwater factor several years before the year 2015 due to political or institutional instead of physical constraints.

The supply of irrigation water is expected to shrink considerably in the near future as shown in Table D-II-2. Existing on-farm storage reservoirs and in-season recovery of irrigation water and rainfall are projected to remain unchanged. The decrease will come from groundwater as the area's aquifers are exhausted. By the turn of the century available irrigation water is estimated to be down by 204,000 acre-feet, a 43% reduction. By 2015 groundwater's yield is expected to approach its recharge level of 35,600 acre-feet per year. The total shortfall at 2015 is estimated to be 372,400 acre-feet, a 77% reduction.

(2). Acres of Irrigated Crops. The reduction in available irrigation water translates into a substantial reduction in irrigated acreage. By 2000 the acreage of irrigated crops is expected to be down to 139,275, a 42% reduction. Approximately 102,502 acres would be shifted to dryland farming practices. Soybeans will make up the majority (93%) of the dryland crops with 71,631 acres single cropped and 24,127 double cropped with wheat. The remainder will be comprised of grain sorghum at 3,069 acres and corn at 2,373. By 2015 irrigated crops are projected to be down to 54,648 acres, a 77% reduction. The remaining 187,129 acres will also be shifted to dryland practices which will be comprised of 130,772 acres of single cropped soybeans, 44,046 acres of double cropped soybeans, 5,602 acres of grain sorghum, and 4,333 acres of corn. Projected without-project land use by crop is presented in Table D-II-3 for both irrigated and dryland crops.

Table D-II-1
Present (1996) Land Use
Grand Prairie Area Demonstration Project
(October 1996 Price Levels)

Item	Percent Dist.	Acres 1/	Water Used	Unit	Price	Yield	Gross Revenues	Production Cost 2/	Net Return	Weighted Net Return
			(ac-ft)		($)		($)	($)	($)	($)
Rice	36.3%	87,833	223,900	cwt.	6.90	65.25	450.23	331.27	118.96	43.21
Soybeans	33.6%	81,129	142,100	bu.	5.94	45	267.30	206.51	60.79	20.40
Double-Crop	23.5%	56,909					372.15	284.33	87.82	20.67
Soybeans			77,500	bu.	5.94	40				
Wheat			0	bu.	2.99	45				
Grain Sorghum	3.0%	7,238	12,000	cwt.	3.90	70	273.00	210.27	62.73	1.88
Corn	2.2%	5,598	11,300	bu.	2.38	175	416.50	312.09	104.41	2.31
Aquaculture	1.3%	3,070	14,400	lb.	0.7936	4,750	3,769.60	2,947.29	822.31	10.44
Total	100.0%	241,777	481,200							98.92

1/ Cleared acres subject to irrigation.

2/ Excludes charges for land and management.

Table D-II-2
Present (1996) and Projected Demand and Supply for Irrigation Water
Without-Project Conditions
Grand Prairie Area Demonstration Project
(Acre-Feet)

Item	1996	2000	2007	2015	2056
Demand	481,195	481,195	481,195	481,195	481,195
Supply					
Groundwater	408,007	204,004	125,403	35,574	35,574
Storage Reservoirs and Tailwater Recovery	73,188	73,188	73,188	73,188	73,188
Total	481,195	277,192	198,591	108,762	108,762
Shortfall	0	204,003	282,604	372,433	372,433

Table D-II-3

Present (1996) and Projected Land Use

Without-Project Conditions

Grand Prairie Area Demonstration Project

(Acres)

Item	1996	2000	2007	2015	2056
Irrigated Cropland					
Rice	87,833	50,596	36,249	19,853	19,853
Soybeans Single-Cropped	81,129	46,735	33,483	18,337	18,337
Soybeans Double-Cropped	56,909	32,782	23,486	12,863	12,863
Grain Sorghum	7,238	4,169	2,987	1,636	1,636
Corn	5,598	3,225	2,310	1,265	1,265
Aquaculture	3,070	1,768	1,267	694	694
Total	241,777	139,275	99,782	54,648	54,648
Dryland Cropland					
Soybeans Single-Cropped	0	71,631	99,230	130,772	130,772
Soybeans Double-Cropped	0	24,127	33,423	44,046	44,046
Grain Sorghum	0	3,069	4,251	5,602	5,602
Corn	0	2,373	3,288	4,333	4,333
Abandoned Fish Ponds	0	1,302	1,803	2,376	2,376
Total	0	102,502	141,995	187,129	187,129
Total Cropland and Aquaculture	241,777	241,777	241,777	241,777	241,777

It is recognized that the area farmers may choose to partially irrigate their crops instead of a true or complete shift to dryland practices as their existing water sources are depleted. This is not viewed as the "best" or optimum use of their water resources. Net farm income over the project life would be maximized by fully irrigating all of the acreage that their water sources can supply with a shift of the remaining acreage to dryland crops. For this reason, a shift to dryland practices instead of partial irrigation was chosen as the most likely future without-project condition.

(3). Crop Data. The calculation of future crop budgets was accomplished by projecting both crop yields per acre and levels of crop production inputs per acre. The price levels for both crops and production costs were held constant at 1996 price levels. The methodology used to project crop yields and levels of production inputs is consistent with that used for traditional Memphis District flood control studies. A first degree polynomial function was fit to crop budget input and output indices published by the Economic Research Service of the U.S. Department of Agriculture. The resulting regression equations and indexes are presented in Table D-II-4. The correlation coefficients for the output and input equations were .94873 and .37086, respectively. The output equation tested statistically significant at the 1 percent level of significance, while the input equation tested significant at the 2 percent level. The indexes were applied to the present (1996) values in Tables D-II-5 and D-II-6 to yield the future values used in this analysis. Projected without-project crop data for irrigated crops is presented in Table D-II-5. Projected without-project crop data for dryland crops is presented in Table D-II-6.

(4). Present and Future Net Revenue. Total net revenue or net farm income begins to decrease substantially from the current level of $23.9 million by the turn of the century as groundwater is exhausted. By the year 2000 net farm income has dropped to $17.1 million dollars. By 2015 net farm income has decreased to $14.9 million. Rice and soybeans are the major contributors to net farm income at $10.4 million and $9.9 million, respectively followed by aquaculture at $2.5 million. Net farm income under without-project conditions is presented in Table D-II-7 for the period 1995 through 2063.

Table D-II-4
Projection Factors for Crop Yields and Production Inputs
Grand Prairie Area Demonstration Project

Item	Equation	Year					
		1995	1996	2000	2007	2015	2056
Crop Yields	y = 0.0167348X - 32.4349327	1.00	1.01	1.06	1.14	1.25	1.99
Production Inputs	y = 0.0051037X - 9.1882495	1.00	1.00	1.02	1.05	1.09	1.31

Table D-II-5
Present (1996) and Projected Crop Yields, Gross Returns, Production Costs, and Net Returns per Acre
Irrigated Crops, Without-Project Conditions
Grand Prairie Area Demonstration Project
(October 1996 Price Levels)

Item	Year				
	1996	2000	2007	2015	2056
Rice					
Yield (bu)	146.64	153.18	165.40	180.57	283.12
Price ($/cwt)	6.90	6.90	6.90	6.90	6.90
Gross Return ($)	455.30	475.62	513.57	560.67	879.09
Production Cost ($)	332.72	338.54	348.98	361.31	431.69
Net Return ($)	122.58	137.08	164.59	199.36	447.40
Soybeans Single-Cropped					
Yield (bu)	45.51	47.54	51.33	56.04	87.87
Price ($/bu)	5.94	5.94	5.94	5.94	5.94
Gross Return ($)	270.32	282.39	304.90	332.88	521.95
Production Cost ($)	207.42	211.04	217.55	225.24	269.11
Net Return ($)	62.90	71.35	87.35	107.64	252.84
Soybeans Double-Cropped					
Wheat					
Yield (bu)	45.51	47.54	50.37	56.04	95.11
Price ($/bu)	2.99	2.99	2.99	2.99	2.99
Soybeans					
Yield (bu)	40.45	42.26	44.78	49.81	84.55
Price ($/bu)	5.94	5.94	5.94	5.94	5.94
Gross Return ($)	376.35	393.17	416.60	463.43	786.61
Production Cost ($)	285.58	290.57	299.53	310.12	370.52
Net Return ($)	90.78	102.60	117.07	153.31	416.09
Grain Sorghum					
Yield (cwt)	70.79	73.95	79.85	87.17	136.68
Price ($/cwt)	3.90	3.90	3.90	3.90	3.90
Gross Return ($)	276.08	288.41	311.42	339.96	533.05
Production Cost ($)	211.19	214.88	221.51	229.34	274.01
Net Return ($)	64.89	73.53	89.91	110.62	259.04
Corn					
Yield (bu)	176.97	184.87	199.62	217.93	341.70
Price ($/bu)	2.38	2.38	2.38	2.38	2.38
Gross Return ($)	421.20	439.99	475.10	518.67	813.25
Production Cost ($)	313.46	318.94	328.78	340.39	406.70
Net Return ($)	107.74	121.05	146.32	178.28	406.55
Aquaculture					
Yield (lbs)	4,803.56	5,017.81	5,418.29	5,915.27	9,274.71
Price ($/lb)	0.79	0.79	0.79	0.79	0.79
Gross Return ($)	3,812.11	3,982.13	4,299.95	4,694.36	7,360.41
Production Cost ($)	2,960.22	3,011.95	3,104.87	3,214.58	3,840.72
Net Return ($)	851.88	970.18	1,195.08	1,479.78	3,519.69

Table D-II-6
Present (1996) and Projected Crop Yields, Gross Returns, Production Costs, and Net Returns per Acre
Dryland Crops, Without-Project Conditions
Grand Prairie Area Demonstration Project
(October 1996 Price Levels)

Item	Year				
	1996	2000	2007	2015	2056
Soybeans Single-Cropped					
Yield (bu)	22.25	23.24	25.10	27.40	42.96
Price ($/bu)	5.94	5.94	5.94	5.94	5.94
Gross Return ($)	132.15	138.05	149.09	162.76	255.18
Production Cost ($)	135.25	137.61	141.86	146.87	175.48
Net Return ($)	-3.10	0.44	7.23	15.89	79.70
Soybeans Double-Cropped					
Wheat					
Yield (bu)	45.51	47.54	51.33	56.04	87.87
Price ($/bu)	2.99	2.99	2.99	2.99	2.99
Soybeans					
Yield (bu)	20.23	21.13	22.81	24.91	39.05
Price ($/bu)	5.94	5.94	5.94	5.94	5.94
Gross Return ($)	256.21	267.66	288.97	315.53	494.69
Production Cost ($)	229.80	233.82	241.03	249.55	298.16
Net Return ($)	26.41	33.84	47.94	65.98	196.53
Grain Sorghum					
Yield (cwt)	45.51	47.54	51.33	56.04	87.87
Price ($/cwt)		3.90	3.90	3.90	3.90
Gross Return ($)		185.41	200.19	218.56	342.69
Production Cost ($)	127.13	129.35	133.34	138.05	164.94
Net Return ($)		56.06	66.85	80.51	177.75
Corn					
Yield (bu)	85.96	89.79	96.96	105.85	165.97
Price ($/bu)	2.38	2.38	2.38	2.38	2.38
Gross Return ($)	204.58	213.70	230.76	251.92	395.01
Production Cost ($)	201.13	204.64	210.96	218.41	260.95
Net Return ($)	3.45	9.06	19.80	33.51	134.06

Table D-II-7
Present (1996) and Projected Net Revenues
Without-Project Conditions
Grand Prairie Area Demonstration Project
(October 1996 Price Levels, $000)

Item	1996	2000	2007	2015	2056
Irrigated Crops					
Rice	10,448	6,936	5,966	3,958	8,882
Soybeans-Single	4,932	3,334	2,925	1,974	4,636
Soybeans Double-Cropped	4,998	3,363	2,935	1,972	4,581
Grain Sorghum	454	307	269	181	424
Corn	584	390	338	226	514
Total Irrigated Net Revenues	21,416	14,331	12,433	8,310	19,037
Dryland Crops					
Soybeans-Single	0	31	718	2,077	10,423
Soybeans Double-Cropped	0	816	1,602	2,906	8,656
Grain Sorghum	0	172	284	451	996
Corn	0	22	65	145	581
Total Dryland Net Revenues	0	1,041	2,669	5,580	20,656
Aquaculture	2,524	1,715	1,514	1,027	2,443
Total	23,941	17,087	16,616	14,917	42,136

D-II-6. WITH-PROJECT CONDITIONS.

None of the four alternatives provides all of the irrigation water needed all of the time. However, all consistently provide a majority of the area's average year's water needs. Major components of the project are increased conservation levels, additional on-farm storage reservoirs, and the import system bringing water from the White River with the withdrawal limitation of the Current State Water Plan.

a. Demand for Irrigation Water. The first step in implementing the project was to look at alternative ways to cut the demand for irrigation water. This had to be done since there was no source available that would provide for all of the area's projected unmet needs. NRCS studied the area's water usage and determined it to be at a 60% efficiency level. This means that of all the water drawn from the area's sources, only 60% actually gets to the fields and is used by the crops. They then developed additional conservation measures that could be applied to the area's farms to make them more efficient in their water use. The optimum conservation level was found to be 70% efficiency. Additional information on the selection of this level can be found in the NRCS Appendix of this report. This level of conservation was used in all of the alternatives presented in this section.

b. Supply of Irrigation Water. The supply model developed by the Memphis District in conjunction with HEC was run for each alternative for the period 1940 through 1986. Table D-II-8 shows that Alternative 7B can provide an average of 243,900 additional acre-feet of water per year for a total of 421,404 acre-feet per year. This level will provide approximately 87.6% of an average year's crop-season need. Even with this project in place there will be an unmet need or shortage of 59,791 acre-feet which will mean a portion of the area will convert to dryland practices.

c. Acres of Each Crop. The shortage in available irrigation water directly translates into a reduction in irrigated acreage. By 2015 the acreage of irrigated crops is expected to decline to 211,735, a 12.4% reduction. Approximately 30,042 acres are expected to be shifted from irrigated practices. Soybeans will make up the majority (93%) of the dryland acreage with 20,995 acres single cropped and 7,071 double cropped with wheat. The remainder of the crops will be comprised of grain sorghum at 899 acres and corn at 696. Irrigated crops would be composed of 76,919 acres of rice, 71,048 acres of single cropped soybeans, 49,838 acres of double cropped soybeans, 6,339 acres of grain sorghum, 4,902 acres of corn, and 2,689 acres of fish ponds. Projected with-project land use by crop is presented in Table D-II-9 for both irrigated and dryland crops.

Table D-II-8
Present (1996) and Projected Demand and Supply of Irrigation Water
Alternative 7B
Grand Prairie Area Demonstration Project
(Acre-Feet)

Item	Year				
	1996	2000	2007	2015	2056
Demand	481,195	481,195	481,195	481,195	481,195
Supply					
Conservation	0	0	68,742	68,742	68,742
Groundwater	408,007	204,004	95,365	35,574	35,574
Import System	0	0	243,900	243,900	243,900
Existing Sources	73,188	73,188	73,188	73,188	73,188
Total	481,195	277,192	481,195	421,404	421,404
Shortfall	0	204,003	0	59,791	59,791

Table D-II-9

Present (1996) and Projected Land Use

Alternative 7B

Grand Prairie Area Demonstration Project

(Acres)

Item	Year				
	1996	2000	2007	2015	2056
Irrigated Cropland					
Rice	87,833	50,596	87,833	76,919	76,919
Soybeans Single-Cropped	81,129	46,735	81,129	71,048	71,048
Soybeans Double-Cropped	56,909	32,782	56,909	49,838	49,838
Grain Sorghum	7,238	4,169	7,238	6,339	6,339
Corn	5,598	3,225	5,598	4,902	4,902
Aquaculture	3,070	1,768	3,070	2,689	2,689
Total	241,777	139,275	241,777	211,735	211,735
Dryland Cropland					
Soybeans Single-Cropped	0	71,631	0	20,995	20,995
Soybeans Double-Cropped	0	24,127	0	7,071	7,071
Grain Sorghum	0	3,069	0	899	899
Corn	0	2,373	0	696	696
Abandoned Fish Ponds	0	1,302	0	381	381
Total	0	101,200	0	30,042	30,042
Total Cropland	241,777	241,777	241,777	241,777	241,777

d. Crop Data. The crop data per acre is essentially the same as for existing conditions with one exception. There will be as an added beneficial effect a reduction in the on-farm pumping cost of irrigation water. Presently, approximately 85% of irrigation water comes from groundwater and 15% from surface water. With the project approximately 91% of the water will come from surface water and only about 9% from groundwater. Groundwater is pumped from depths of 200 feet or more. Surface water is pumped an average of 15 feet. Because of this, surface water requires significantly lower energy, maintenance, and equipment costs to apply to the area's fields than does groundwater. The capital investment of deep wells is also much greater than surface water relift pumps. The current (1996) irrigation costs per acre under both without- and with-project conditions and current and projected cost reductions per acre are presented in Table D-II-10. All other data for the irrigated crops are presented in Table D-II-11. Dryland crop data per acre is the same as presented in Table D-II-6.

e. Net Revenue. By 2015 total net revenue or net farm income is expected to increase substantially over without-project conditions with completion of the project. Net farm income is expected to be $45.7 million versus $14.9 million without the project. Rice and soybeans are the major contributors to net farm income at $19.6 million and $19.9 million, respectively followed by aquaculture at $4.3 million. By the end of the project's economic life net farm income is expected to increase to $96.9 million. Net farm income under with-project conditions is presented in Table D-II-12 for the period 1996 through 2056.

D-II-7. BENEFITS.

All project benefits are based on current price levels, estimated over a 50-year project life plus the installation period, and discounted to the end of the project installation period using the current Federal discount rate. The project benefits consist of irrigation benefits and waterfowl benefits. Irrigation benefits consist of the difference between with- and without-project revenue streams. They are comprised of the increased crop production of maintaining irrigation practices versus dryland practices and any efficiencies or cost savings of using surface water in place of groundwater. A detailed description of the waterfowl benefits can be found in the EIS. The following sections present the methodologies used to calculate each of the benefit categories in this analysis.

Table D-II-10
Present (1996) Irrigation Costs per Acre and
Present and Future With-Project Irrigation Cost Reductions
Irrigated Crops, Alternative 7B
Grand Prairie Area Demonstration Project
(October 1996 Price Levels)

Item	1996 Irrigation Cost per Acre		Reduction in Irrigation Cost per Acre 1/				
	Without-Project	With-Project	1996	2000	2007	2015	2056
	($)	($)	($)	($)	($)	($)	($)
Rice	149.68	99.32	50.36	51.46	53.05	54.93	65.63
Soybeans Single-Cropped	85.97	57.05	28.92	29.55	30.47	31.54	37.69
Soybeans Double-Cropped	84.26	55.90	28.36	28.98	29.88	30.93	36.96
Grain Sorghum	59.77	39.65	20.12	20.56	21.20	21.94	26.22
Corn	105.01	69.62	35.39	36.17	37.28	38.60	46.12
Composite Acre	108.56	72.03	36.53	37.34	38.48	39.84	47.61

1/ Cost reduction due to switch from groundwater to surface water. Under without-project conditions the source of irrigation water is 85% groundwater and 15% surface water. Under with-project conditions the source of irrigation water is 91% surface water and 9% groundwater. Surface water requires significantly lower capital investment, energy, and maintenance costs to pump onto the farm fields.

Table D-II-11
Present (1996) and Projected Crop Yields, Gross Returns, Production Costs, and Net Returns per Acre
Irrigated Crops, Alternative 7B
Grand Prairie Area Demonstration Project
(October 1996 Price Levels)

Item	Year				
	1996	2000	2007	2015	2056
Rice					
Yield (bu)	146.64	153.18	165.40	180.57	283.12
Price ($/cwt)	6.90	6.90	6.90	6.90	6.90
Gross Return ($)	455.30	475.62	513.57	560.67	879.09
Production Cost ($)	282.36	287.08	295.93	306.38	366.06
Net Return ($)	172.94	188.54	217.64	254.29	513.03
Soybeans Single-Cropped					
Yield (bu)	45.51	47.54	51.33	56.04	87.87
Price ($/bu)	5.94	5.94	5.94	5.94	5.94
Gross Return ($)	270.32	282.39	304.90	332.88	521.95
Production Cost ($)	178.50	181.49	187.08	193.70	231.42
Net Return ($)	91.82	100.90	117.82	139.18	290.53
Soybeans Double-Cropped					
Wheat					
Yield (bu)	45.51	47.54	50.37	56.04	95.11
Price ($/bu)	2.99	2.99	2.99	2.99	2.99
Soybeans					
Yield (bu)	40.45	42.26	44.78	49.81	84.55
Price ($/bu)	5.94	5.94	5.94	5.94	5.94
Gross Return ($)	376.35	393.17	416.60	463.43	786.61
Production Cost ($)	257.22	261.59	269.65	279.19	333.56
Net Return ($)	119.14	131.58	146.95	184.24	453.05
Grain Sorghum					
Yield (cwt)	70.79	73.95	79.85	87.17	136.68
Price ($/cwt)	3.90	3.90	3.90	3.90	3.90
Gross Return ($)	276.08	288.41	311.42	339.96	533.05
Production Cost ($)	191.07	194.32	200.31	207.40	247.79
Net Return ($)	85.01	94.09	111.11	132.56	285.26
Corn					
Yield (bu)	176.97	184.87	199.62	217.93	341.70
Price ($/bu)	2.38	2.38	2.38	2.38	2.38
Gross Return ($)	421.20	439.99	475.10	518.67	813.25
Production Cost ($)	278.07	282.77	291.50	301.79	360.58
Net Return ($)	143.13	157.22	183.60	216.88	452.67
Aquaculture					
Yield (lbs)	4,803.56	5,017.81	5,418.29	5,915.27	9,274.71
Price ($/lb)	0.79	0.79	0.79	0.79	0.79
Gross Return ($)	3,812.11	3,982.13	4,299.95	4,694.36	7,360.41
Production Cost ($)	2,842.62	2,842.62	2,842.62	2,842.62	2,842.62
Net Return ($)	969.49	1139.51	1457.33	1851.74	4517.79

Table D-II-12
Present (1996) and Projected Net Revenues
Irrigated Crops, Alternative 7B
Grand Prairie Area Demonstration Project
(October 1996 Price Levels, $000)

Item	Year				
	1996	2000	2007	2015	2056
Irrigated Crops					
Rice	10,448	6,936	19,116	19,560	39,462
Soybeans-Single	4,932	3,334	9,559	9,888	20,641
Soybeans Double-Cropped	4,998	3,363	8,813	9,182	19,591
Grain Sorghum	454	307	804	840	1,808
Corn	584	390	1,028	1,063	2,219
Total Irrigated Net Revenues	21,416	14,331	39,320	40,534	83,721
Dryland Crops					
Soybeans-Single	0	31	0	334	1,673
Soybeans Double-Cropped	0	816	0	467	1,390
Grain Sorghum	0	172	0	72	160
Corn	0	22	0	23	93
Total Dryland Net Revenues	0	1,041	0	896	3,316
Aquaculture	2,524	1,715	4,007	4,286	9,831
Total	23,941	17,087	43,327	45,716	96,868

a. Irrigation Benefits. Irrigation benefits were derived from maintaining as high a level of irrigation practices as possible and from lower irrigation costs due to reduced pumping costs as surface water is substituted for groundwater. Without the project, the aquifer is expected be depleted to such a point that a large portion of the presently irrigated crops will shift to dryland practices. As the groundwater available without the project declines, the irrigated acres will shift to dryland crops. With the project import water is provided to replace the lost groundwater. This allows irrigation practices to continue to the level at which the import sources can sustain. Irrigation benefits are the difference in total net revenues between the with- and without-project conditions. Total revenues for Alternative 1-SWP and without-project conditions and project benefits during the project implementation period and by decade throughout the project life are presented in Table D-II-13. The benefits begin in 2001 as conservation measures and on-farm storage reservoirs are constructed. The majority of the benefits come from soybeans and rice with aquaculture and corn adding slightly to the totals. Average annual equivalent revenues and benefits are presented in Table D-II-13. Benefits under traditional methods are estimated at $35.6 million annually while annual benefits under risk-based methods are estimated at $35.7 million.

(1). Risk Analysis. This section provides an estimate of the risk inherent with the economic data used to evaluate the effects of the project. It addresses the areas where risk and uncertainty are known to exist so that the economic performance of a project can be expressed in terms of probability distributions. This analysis was performed using Excel spreadsheets in conjunction with an add-on simulation model entitled @Risk. It incorporates the range (maximum and minimum) of possible values for an input variable and specifies the statistical distribution of likely outcomes over the chosen range. In the case where a normal distribution is assumed, 68% percent of the occurrences of a particular outcome fall within (plus or minus) one standard deviation, on either side of the mean, and 95% percent within two standard deviations on either side of the mean. The initial step in constructing an @Risk simulation is to identify the sources of uncertainty. Some sources of risk and uncertainty arise from measurement errors, small sample sizes, estimation and forecasting errors, and modeling errors. The variables affecting the benefits, the shape of their distributions, and the amounts they are allowed to vary during the simulation are presented in Table D-II-14.

The @Risk simulation was performed utilizing 3,000 iterations, or different combinations, of the economic variables. The 68 and 95 percent confidence bands around the mean results are plus/minus one and two standard deviations, respectively. An additional step was taken to identify which variable(s) contributed the most to uncertainty. The simulation was run again, varying each variable individually while holding the remaining variables constant. The most important variable was the 25% variation in crop yield followed by the 15% variation in crop prices. The 2 standard deviations in the input projection factor, 10% variation in crop mix, and variation in interest rate had negligible effect on the annual benefits.

Table D-II-13
Present (1996) and Projected Irrigation Benefits
Alternative 7B
Grand Prairie Area Demonstration Project
(October 1996 Price Levels, $000)

Year	Without-Project	With-Project	Benefit
1996	23,941	23,941	0
2000	17,087	17,087	0
2001	17,069	17,598	528
2002	17,039	18,118	1,080
2003	16,990	18,644	1,654
2004	16,923	19,173	2,250
2005	16,840	26,798	9,959
2006	16,734	27,432	10,698
2007	16,616	43,327	26,711
2008	16,473	44,264	27,791
2009	16,313	45,215	28,902
2010	16,130	46,175	30,045
2011	15,930	47,147	31,217
2012	15,712	48,143	32,431
2013	15,464	46,873	31,408
2014	15,202	45,784	30,582
2015	14,917	45,716	30,799
2016	15,414	46,672	31,257
2026	20,813	56,937	36,124
2036	26,996	68,605	41,609
2046	34,065	81,852	47,787
2056	42,136	96,868	54,732
Average Annual Equivalent Values @ 7.375% Discount Rate			
Traditional	30,294	65,926	35,632
Risk Based			
Mean			35,659
Standard Deviation			6,325

Table D-II-14

Results of Risk Analysis

Means and Standard Deviations of Average Annual Equivalent Irrigation Benefits Resulting from Varying Individual Risk-Based Items

Plus/Minus Two Standard Deviations

Alternative 7B, Grand Prairie Area Demonstration Project

(October 1996 Price Levels, $000)

Item	Annual Benefit		Distribution	Variation in Item
	Mean	Standard Deviation		
Crop Yields	35,631	5,449	Truncated Normal	25%
Crop Prices	35,632	2,518	Truncated Normal	15%
Output Projection Factors	35,647	1,179	Truncated Normal	2 Standard Deviations
Production Cost	35,632	720	Truncated Normal	5%
Crop Mix	35,632	355	Truncated Normal	10%
Input Projection Factor	35,631	174	Truncated Normal	2 Standard Deviations
Interest Rate	35,636	61	Truncated Normal	Allows interest rate to range between 7.25% and 8.25%
All Items	35,659	6,325		

(2). Reliability Analysis. This section provides information on the reliability of the project in providing adequate water to irrigate the project area. There are two factors influencing the reliability of the project which are: (1) The demand for irrigation water and (2) The amount of water that the project can provide. The mean or average demand before conservation to irrigate the entire 241,777 acre project area for is 481,195 acre-feet with a standard deviation of 77,730 acre-feet. After conservation the demand is effectively reduced by 68,742 acre-feet to 412,453 with a standard deviation of 66,626. The demand varied greatly over the 47 year period of record. After the conservation practices were implemented, it varied from a low of 303,839 acre-feet to a high of 604,143 acre-feet. The wide range between the two extremes is due to the unpredictability of rainfall and wide variation in temperatures from year to year. Lower rainfall and higher temperature levels usually increase the need for supplemental irrigation water. Higher rainfall and lower temperature levels usually decrease the need for supplemental irrigation water. The project is also limited to the amount of water that can be imported from the White River. This amount varies from year to year depending on the precipitation falling upstream of the pumping station. The mean demand met by Alternative 7B is 421,404 acre-feet (includes 68,742 acre-feet of conservation) with a standard deviation of 101,861 acre-feet which translates into a mean irrigated acreage of 209,046 acres and a standard deviation of 50,530 acres. This means that on an average year approximately 87.6% of the project area can be fully irrigated (421,404 acre-feet/481,195 acre-feet).

Another way of looking at the reliability of the project in meeting irrigation demands is to see how often all of the area could be irrigated. Alternative 7B could provide sufficient water to irrigate the entire 241,777 acre area 57.4% of the time or 27 years out of the 47 year period of record. This does not mean that for the remaining 42.6% of the time no irrigation would occur. Irrigation would always take place, just at lesser than maximum levels. Figures D-II-1 and D-II-2 graphically present the percent of an average year's irrigated acreage and the percent of time all of the area is irrigated based on the 47 year period of record. Table D-II-15 presents the above information for all alternatives.

(3). Summary of Irrigation Benefits. A summary of the irrigation benefits by alternative is presented in Table D-II-16. The benefits are presented for traditional methodology which is based on the average or best estimate and for risk-based results which are based on "Monte Carlo" simulation. Means and standard deviations are presented for the risk-based benefits

Figure D-II-1. Percent of Mean Year's Irrigated Crop Acreage Provided
Grand Prairie Demonstration Project
Alternatives 7A-D

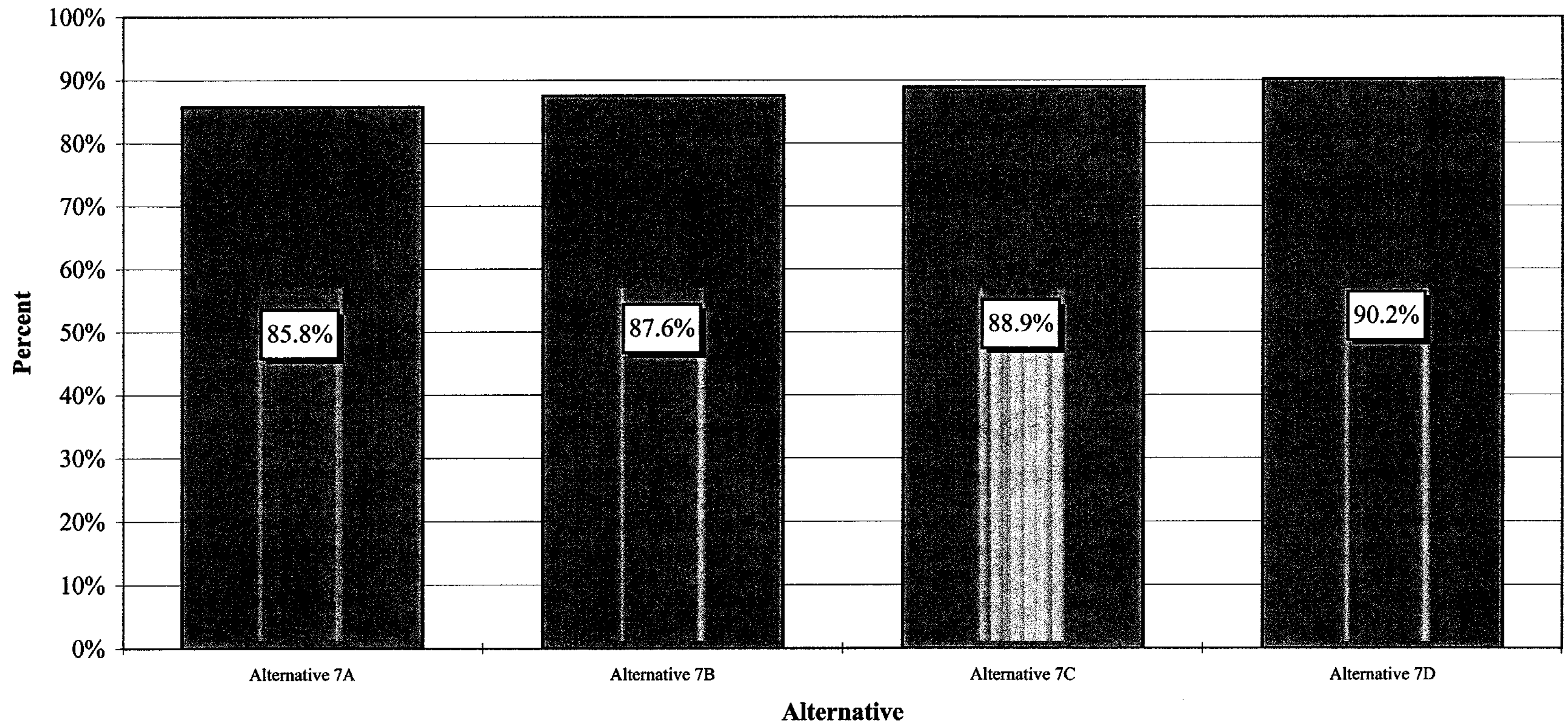

Figure D-II-2. Percent of Time All Cropland is Irrigated
Grand Prairie Demonstration Project
Alternative 7A-D

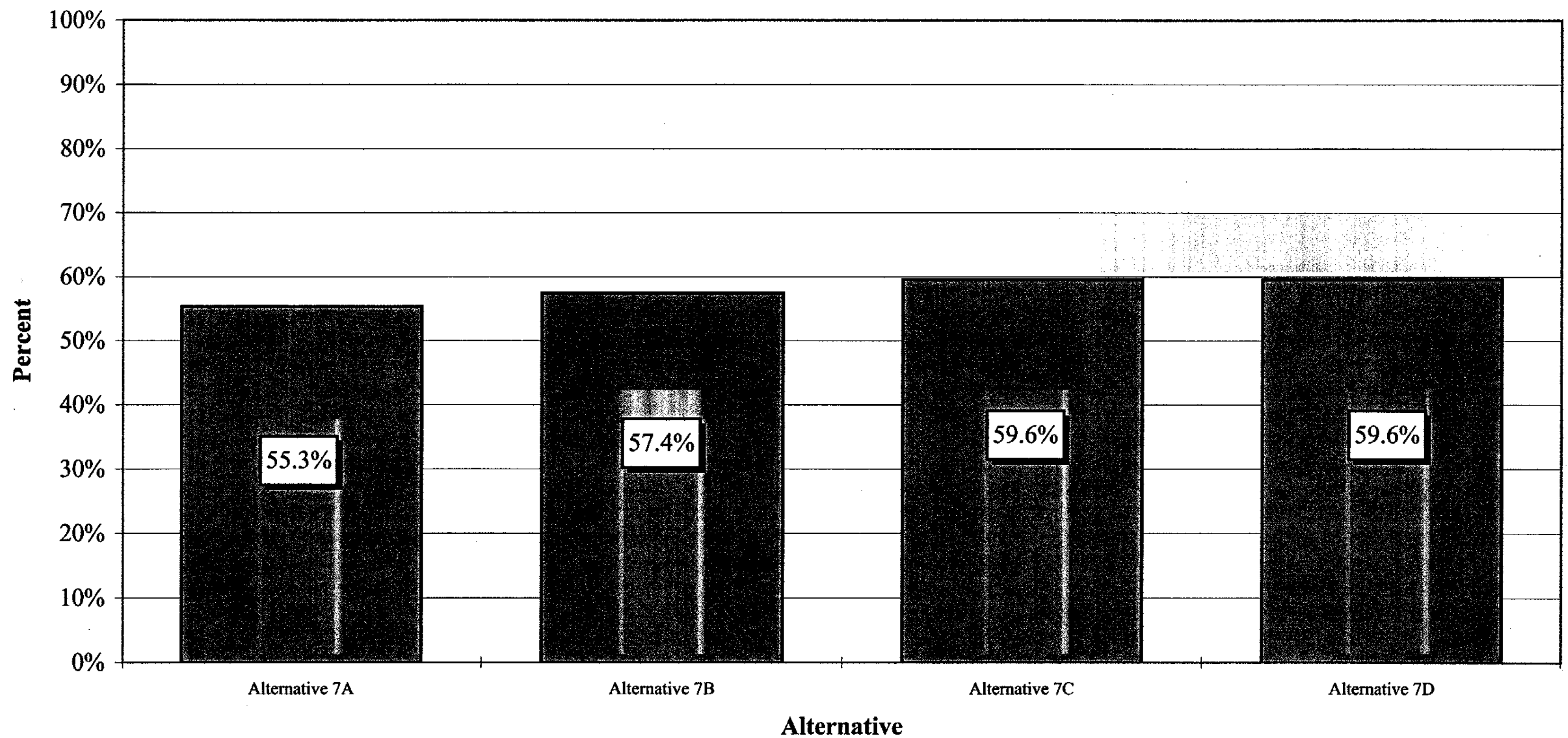

Table D-II-15

Summary of Reliability Information

Grand Prairie Area Demonstration Project

Alternative	Mean Acres Irrigated (Acres)	Standard Deviation (Acres)	Percent of Mean Year's Irrigated Acreage	Percent of Time All of Area Irrigated (47 Year Record)
Alternative 7A	204,810	51,836	85.8%	55.3%
Alternative 7B	209,046	50,530	87.6%	57.4%
Alternative 7C	212,185	49,198	88.9%	59.6%
Alternative 7D	215,231	48,719	90.2%	59.6%

Table D-II-16

Summary of Annual Irrigation Benefits

Grand Prairie Area Demonstration Project

(October 1996 Price Levels, 7.375% Discount Rate)

Alternative	Traditional	Risk Based Mean	Risk Based Standard Deviation
	($000)	($000)	($000)
Alternative 7A	34,796	34,823	6,165
Alternative 7B	35,632	35,659	6,325
Alternative 7C	36,238	36,266	6,441
Alternative 7D	36,816	36,844	6,552

b. Waterfowl Benefits. Waterfowl benefits accrue to the project from the preparation of 45,000 acres of rice fields for winter waterfowl use. Detailed modeling reveals that if 45,000 acres are prepared, on average 38,500 acres can be flooded on an annual basis. This figure includes approximately 17,400 acres flooded under without-project conditions and 21,100 under with-project conditions. Benefits are claimed only for the 21,100 acre figure. A detailed description of these benefits and their computations is presented in the EIS. Table D-II-17 presents the estimated benefits by year and annual waterfowl benefits for Alternative 7B. Table D-II-18 presents a summary of the annual waterfowl benefits by alternative.

c. Total Annual Benefits. Total annual benefits accruing to Alternative 7B are estimated at $36,132,000. Irrigation benefits account for $35,659,000 (99%) of the project benefits. Waterfowl benefits comprise the remaining $473,000 (1%). A summary of the annual benefits for all alternatives is presented in Table D-II-19.

D-II-8. COSTS.

The project costs like the annual benefits are based on current price levels, estimated over a 50-year project life plus the installation period, and discounted to the end of the project installation period using the current Federal discount rate. The annual costs consist of interest, sinking fund, operation, maintenance, and replacement charges. Also included in the annual costs are negative effects on navigation on the White River and potential induced flooding effects on existing streams in the project area which are used to convey irrigation flows.

a. First Costs. Project costs for the off-farm component of Alternative 7B total $201,928,000 and are presented in Table D-II-20. The largest part of the cost is the cost associated with the canals which account for approximately 46% of the off-farm cost. This cost includes the excavation of the canals plus the structures necessary to carry the water underneath existing roads and streams where necessary. The remaining off-farm costs are for the pumping plant, relocations, lands and damages, diversion structures, cultural resources, mitigation, contingencies, engineering and design, and construction management. Total project costs for the on-farm component of Alternative 7B are $68,584,000 (Table D-II-21). The largest component of these costs is for the storage reservoirs which accounts for approximately 45% of the on-farm cost. The remaining on-farm costs are for pipelines, pumps, water control structures, tailwater recovery system, and technical assistance. All costs are based on October 1996 price levels and are assumed to be end of year expenditures.

b. Annual Interest and Sinking Fund Costs. The annual interest and sinking fund costs for both the off-farm and the on-farm components of Alternative 7B are presented in Table D-II-22. All annual costs are based on a reference point at the end of year 2007, the current discount rate of 7.375 percent, and a 50 year period of analysis. Annual interest charges are approximately $23.8 million. Annual sinking fund charges are slightly less than $0.7 million.

Table D-II-17
Average Annual Equivalent Waterfowl Benefits
Alternative 7B
Grand Prairie Area Demonstration Project
(October 1996 Price Levels, 7.375% Discount Rate)

Year	Benefit
	($)
2005	150,576
2006	150,576
2007	449,480
2016	449,480
2026	449,480
2036	449,480
2046	449,480
2056	449,480
Average Annual Equivalent @ 7.375%	473,000

Table D-II-18

Average Annual Equivalent Waterfowl Benefits

Grand Prairie Area Demonstration Project

(October 1996 Price Levels, 7.375% Discount Rate)

Alternative	Benefit ($)
Alternative 7A	467,000
Alternative 7B	473,000
Alternative 7C	478,000
Alternative 7D	487,000

Table D-II-19

Summary of Average Annual Equivalent Benefits

Grand Prairie Area Demonstration Project

(October 1996 Price Levels, 7.375% Discount Rate, $000)

Alternative	Irrigation	Waterfowl	Total
	($)	($)	($)
Alternative 7A	34,823	467	35,290
Alternative 7B	35,659	473	36,132
Alternative 7C	36,266	478	36,744
Alternative 7D	36,844	487	37,331

Table D-II-20

Cost Schedule for Off-Farm Component of Project (Import System and Pumping Station)

Alternative 7B

Grand Prairie Area Demonstration Project

(October 1996 Price Levels, $000)

Item	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Reach 12	Reach 13	Reach 14	Total
Lands & Damages	258		569	599	1,142	845	745	969	965	510	1,672	785	853	997	10,909
Relocations			548	3,583	193	431	323	1,776	1,396	381	2,027	748	508	12	11,926
Channels and Canals			3,895	5,008	9,432	8,390	3,689	7,971	12,796	8,023	13,296	4,475	9,149	6,956	93,080
Pumping Plant	28,312	9,487													37,799
Diversion Structures						897	693	897	897		763				4,147
Cultural Resources	20		200	30	200	180	90	40	170	80	80		50	480	1,620
Mitigation	28		10	1	16	13	3	3	4	2	15	14		14	123
PE&D	973		988	1,405	1,316	1,260	727	746	1,329	672	1,677	848	1,097	810	13,848
Construction Mgt.	1,700	569	267	515	576	583	282	638	906	504	965	314	580	418	8,817
Contingencies	1,800	503	706	1,366	1,530	1,545	748	1,692	2,399	1,337	2,557	831	1,536	1,109	19,659
Total Cost	33,091	10,559	7,183	12,507	14,405	14,144	7,300	14,732	20,862	11,509	23,052	8,015	13,773	10,796	201,928

Table D-II-21

Cost Schedule for On-Farm Component of Project

Alternative 7B

Grand Prairie Area Demonstration Project

(October 1996 Price Levels)

FY	Storage Reservoirs	On-Farm Pipelines	Tailwater Recovery	On-Farm Pumps	Water Control Structures	Sub-Total	Technical Assistance	Total First Cost
2001	4,416,000	2,422,000	313,000	1,005,000	363,000	8,519,000	1,278,000	9,797,000
2002	4,416,000	2,422,000	313,000	1,005,000	363,000	8,519,000	1,278,000	9,797,000
2003	4,416,000	2,422,000	313,000	1,005,000	363,000	8,519,000	1,279,000	9,798,000
2004	4,416,000	2,422,000	313,000	1,005,000	363,000	8,519,000	1,279,000	9,798,000
2005	4,416,000	2,422,000	313,000	1,005,000	363,000	8,519,000	1,279,000	9,798,000
2006	4,416,000	2,422,000	313,000	1,005,000	363,000	8,519,000	1,279,000	9,798,000
2007	4,416,000	2,422,000	313,000	1,005,000	363,000	8,519,000	1,279,000	9,798,000
	30,912,000	16,954,000	2,191,000	7,035,000	2,541,000	59,633,000	8,951,000	68,584,000

Table D-II-22

Average Annual Equivalent Interest and Sinking Fund Costs

Alternative 7B

Grand Prairie Area Demonstration Project

(October 1996 Price Levels, 7.375% Discount Rate)

FY	Off-Farm Cost	On-Farm Cost	Total Cost	Present Value Factor @ 7.375%	Present Value Cost
2001	1,607,000	9,797,000	11,404,000	1.532570	17,477,000
2002	5,508,000	9,797,000	15,305,000	1.427300	21,845,000
2003	18,528,000	9,798,000	28,326,000	1.329270	37,653,000
2004	43,779,000	9,798,000	53,577,000	1.237970	66,327,000
2005	76,696,000	9,798,000	86,494,000	1.152940	99,722,000
2006	44,845,000	9,798,000	54,643,000	1.073750	58,673,000
2007	10,965,000	9,798,000	20,763,000	1.000000	20,763,000
	201,928,000	68,584,000	270,512,000		322,460,000
	Interest			0.07375	23,781,000
	Sinking Fund (50 Year Life)			0.00216	697,000
	Total				24,478,000

c. Annual Operation and Maintenance Costs. Annual off-farm operation, maintenance, and replacement costs for Alternative 7B are presented in Table D-II-23. Annual on-farm costs are presented in Table D-II-24. Both use the end of 2007 as the reference point for discounting, a discount rate of 7.375 percent, and a 50 year period of analysis. Annual costs are $3,729,000 and $910,000 for the off-farm and on-farm components, respectively. Approximately 85% of the off-farm costs are for energy followed by labor at 14% and maintenance and replacements at slightly over 1%. The annual on-farm costs are comprised of operation and maintenance of the new features of the project which includes new reservoirs (43%), pumps (24%), pipelines (23%), tailwater recovery (6%), and water control structures (4%). Any cost of maintaining existing on-farm development is reflected in the without- and with-project crop budgets. Including any existing costs in both the annual costs and the crop budgets would be double-counting. A detailed on-farm analysis, including costs for both existing development and with-project features, is presented in the NRCS section.

d. Induced Crop Damage. Induced flooding effects have been quantified using traditional methodologies used for Corps flood control projects. These methodologies include the use of partial duration stage frequency curves, stage area curves, area frequency curves, and the CACFDAS program. All potential flood effects are agricultural. Only minor (almost insignificant) effects on Mill Bayou and Little Lagrue Bayou have been identified. Since the increases are only between 2 and 4 tenths of a foot, minor modifications might be made to offset these effects. Also, the operation plan may be developed in such a way as to stop the additional flows during rainy periods, alleviating any potential increases in flooding. However, for this analysis, worst case scenarios were assumed in that nothing would be done to offset the potential increases. The potential increase in flood damage for Mill Bayou is approximately $8,000 annually. The potential increase in damage for Little Lagrue Bayou is approximately $4,000 annually. Total annual increases are presented in Table D-II-25.

e. Navigation Impacts. This section presents the effects of the 4 alternatives (7A-D) on White River navigation. Several of the underlying assumptions of the previous analysis (presented in the navigation impact section of Section III) have been refined after review and comment by local shippers, barge line operators, and Memphis District and Mississippi Valley Division level review. Each of the changes are explained in the following sections.

(1). Water Depths. An average of pre- and post-dredge water depths was used in this and the prior analyses. An ongoing dredging program causes the relationship between water depth and river flow to vary throughout the year. Prior to dredging a higher flow is required to obtain a navigable depth. After dredging a lower flow is required for a navigable depth. A 47 year period of record (1940-1986) of these average weekly water depths was developed for without- and with-project conditions and used to evaluate any potential effect on present and projected movements. In the prior analysis it was assumed that a light loaded 7 foot barge could be shipped with an 8 foot average water depth and fully loaded 9 foot barges could be shipped with a 10 foot or greater depth. After meeting with local shippers and barge operators it was determined that at least a 9 foot average water depth would be required to float a light loaded 8 foot barge. An 8 foot barge is the lightest loaded barge that the operators said that they could economically ship. The shippers also said that they could move fully loaded 9.5 foot barges in an average water depth of 10.5 feet or greater.

Table D-II-23

Average Annual Equivalent Off-Farm Operation, Maintenance, and Replacement Costs

Alternative 7B

Grand Prairie Area Demonstration Project

(October 1996 Price Levels, 7.375% Discount Rate)

Fiscal Year	Number of Years Discounted	Large Pumping Station	Small Pumping Stations	Structures	Canals	Total	Present Value Factor @ 7.375%	Present Value of Total
2005	-1	1,473,761	184,991	138,525	33,750	1,831,026	1.07375	1,966,923
2006	0	1,473,761	185,391	138,525	33,750	1,831,426	1.00000	1,833,027
2007	1	2,885,969	314,008	175,298	33,750	3,409,025	0.93132	3,177,128
2008	2	2,885,969	314,408	175,298	33,750	3,409,425	0.86735	2,959,940
2009	3	2,885,969	314,808	175,298	33,750	3,409,825	0.80778	2,757,620
2010	4	2,885,969	315,208	175,298	33,750	3,410,225	0.75229	2,569,089
2011	5	2,885,969	315,608	175,298	33,750	3,410,625	0.70062	2,393,475
2012	6	2,885,969	316,008	175,298	33,750	3,411,025	0.65250	2,229,870
2013	7	2,885,969	316,408	175,298	33,750	3,411,425	0.60768	2,077,430
2014	8	2,885,969	316,808	175,298	33,750	3,411,825	0.56595	1,958,089
2015	9	2,885,969	317,208	175,298	33,750	3,412,225	0.52707	1,803,120
2016	10	2,885,969	317,608	175,298	33,750	3,412,625	0.49087	1,679,867
2017	11	2,885,969	318,008	175,298	33,750	3,413,025	0.45716	1,565,051
2018	12	2,885,969	318,408	175,298	33,750	3,413,425	0.42576	1,458,068
2019	13	2,885,969	318,808	175,298	33,750	3,413,825	0.39651	1,358,373
2020	14	2,885,969	319,208	175,298	33,750	3,414,225	0.36928	1,265,532
2021	15	2,885,969	319,608	175,298	33,750	3,414,625	0.34392	1,179,034
2022	16	2,885,969	320,008	175,298	33,750	3,415,025	0.32029	1,098,410
2023	17	2,885,969	320,408	175,298	33,750	3,415,425	0.29830	1,023,356
2024	18	3,156,104	320,808	175,298	33,750	3,685,960	0.27781	1,039,552
2025	19	2,885,969	321,208	175,298	33,750	3,416,225	0.25873	888,227
2026	20	2,885,969	321,608	175,298	33,750	3,416,625	0.24096	827,510
2027	21	2,885,969	322,008	175,298	33,750	3,417,025	0.22441	770,944
2028	22	2,885,969	322,408	175,298	33,750	3,417,425	0.20899	718,220
2029	23	2,885,969	322,808	175,298	33,750	3,417,825	0.19464	669,138
2030	24	2,885,969	323,208	175,298	33,750	3,418,225	0.18127	623,391
2031	25	2,885,969	323,608	175,298	33,750	3,418,625	0.16882	580,779
2032	26	2,885,969	324,008	175,298	33,750	3,419,025	0.15722	541,061
2033	27	2,885,969	324,408	175,298	33,750	3,419,425	0.14642	504,068
2034	28	2,885,969	324,808	175,298	33,750	3,419,825	0.13637	475,088
2035	29	2,885,969	325,208	175,298	33,750	3,420,225	0.12700	437,519
2036	30	2,885,969	325,608	175,298	33,750	3,420,625	0.11828	407,619
2037	31	2,885,969	326,008	175,298	33,750	3,421,025	0.11015	379,735
2038	32	2,885,969	326,408	175,298	33,750	3,421,425	0.10259	353,794
2039	33	3,397,584	326,808	175,298	33,750	3,933,440	0.09554	378,477
2040	34	2,885,969	327,208	175,298	33,750	3,422,225	0.08898	307,073
2041	35	2,885,969	327,608	175,298	33,750	3,422,625	0.08287	286,085
2042	36	2,885,969	328,008	175,298	33,750	3,423,025	0.07718	266,535
2043	37	2,885,969	328,408	175,298	33,750	3,423,425	0.07188	248,318
2044	38	3,381,774	328,808	175,298	33,750	3,919,630	0.06694	267,199
2045	39	2,885,969	329,208	175,298	33,750	3,424,225	0.06234	215,510
2046	40	2,885,969	329,608	175,298	33,750	3,424,625	0.05806	200,786
2047	41	2,885,969	330,008	175,298	33,750	3,425,025	0.05407	187,052
2048	42	2,885,969	330,408	175,298	33,750	3,425,425	0.05036	174,277
2049	43	2,885,969	330,808	175,298	33,750	3,425,825	0.04690	162,359
2050	44	2,885,969	331,208	175,298	33,750	3,426,225	0.04368	151,264
2051	45	2,885,969	331,608	175,298	33,750	3,426,625	0.04068	140,925
2052	46	2,885,969	332,008	175,298	33,750	3,427,025	0.03788	131,270
2053	47	2,885,969	332,408	175,298	33,750	3,427,425	0.03528	122,303
2054	48	2,885,969	332,808	175,298	33,750	3,427,825	0.03286	115,266
2055	49	2,885,969	333,208	175,298	33,750	3,428,225	0.03060	106,151
2056	50	2,885,969	332,808	175,298	33,750	3,427,825	0.02850	98,833
		148,523,537	16,559,973	9,041,933	1,755,000	175,880,444		49,129,730
Total Annual Cost (50 Year Life)							0.07591	3,729,000

Table D-II-24

Average Annual Equivalent On-Farm Operation, Maintenance, and Replacement Costs

Alternative 7B

Grand Prairie Area Demonstration Project

(October 1996 Price Levels, 7.375% Discount Rate)

Fiscal Year	Number of Years Discounted	Irrigation Pipe	Pumps and Power Unts	Water Control Structures	Reservoirs	Tail Water Recovery	Total	Present Value Factor @ 7.375%	Present Value of Total
2001	-5	24,248	25,154	3,630	44,207	6,269	103,509	1.42730	147,738
2002	-4	48,496	50,309	7,259	88,415	12,539	207,017	1.32927	275,182
2003	-3	72,744	75,463	10,889	132,622	18,808	310,526	1.23797	384,421
2004	-2	96,822	100,441	14,493	176,520	25,034	413,310	1.15294	476,522
2005	-1	121,070	125,596	18,122	220,727	31,303	516,819	1.07375	554,934
2006	0	145,318	150,750	21,752	264,935	37,572	620,327	1.00000	620,327
2007	1	169,566	175,905	25,382	309,142	43,842	723,836	0.93132	674,123
2008	2	169,566	175,905	25,382	309,142	43,842	723,836	0.86735	627,819
2009	3	169,566	175,905	25,382	309,142	43,842	723,836	0.80778	584,700
2010	4	169,566	175,905	25,382	309,142	43,842	723,836	0.75229	544,534
2011	5	169,566	175,905	25,382	309,142	43,842	723,836	0.70062	507,134
2012	6	169,566	175,905	25,382	309,142	43,842	723,836	0.65250	472,303
2013	7	169,566	175,905	25,382	309,142	43,842	723,836	0.60768	439,861
2014	8	169,566	175,905	25,382	309,142	43,842	723,836	0.56595	409,655
2015	9	169,566	175,905	25,382	309,142	43,842	723,836	0.52707	381,512
2016	10	169,566	175,905	25,382	309,142	43,842	723,836	0.49087	355,309
2017	11	169,566	175,905	25,382	309,142	43,842	723,836	0.45716	330,909
2018	12	169,566	175,905	25,382	309,142	43,842	723,836	0.42576	308,180
2019	13	169,566	175,905	25,382	309,142	43,842	723,836	0.39651	287,008
2020	14	169,566	175,905	25,382	309,142	43,842	723,836	0.36928	267,298
2021	15	169,566	175,905	25,382	309,142	43,842	723,836	0.34392	248,942
2022	16	169,566	175,905	25,382	309,142	43,842	723,836	0.32029	231,837
2023	17	169,566	175,905	25,382	309,142	43,842	723,836	0.29830	215,920
2024	18	169,566	175,905	25,382	309,142	43,842	723,836	0.27781	201,089
2025	19	169,566	175,905	25,382	309,142	43,842	723,836	0.25873	187,278
2026	20	169,566	175,905	25,382	309,142	43,842	723,836	0.24096	174,415
2027	21	169,566	175,905	25,382	309,142	43,842	723,836	0.22441	162,436
2028	22	169,566	175,905	25,382	309,142	43,842	723,836	0.20899	151,274
2029	23	169,566	175,905	25,382	309,142	43,842	723,836	0.19464	140,887
2030	24	169,566	175,905	25,382	309,142	43,842	723,836	0.18127	131,210
2031	25	169,566	175,905	25,382	309,142	43,842	723,836	0.16882	122,198
2032	26	169,566	175,905	25,382	309,142	43,842	723,836	0.15722	113,801
2033	27	169,566	175,905	25,382	309,142	43,842	723,836	0.14642	105,984
2034	28	169,566	175,905	25,382	309,142	43,842	723,836	0.13637	98,709
2035	29	169,566	175,905	25,382	309,142	43,842	723,836	0.12700	91,927
2036	30	169,566	175,905	25,382	309,142	43,842	723,836	0.11828	85,615
2037	31	169,566	175,905	25,382	309,142	43,842	723,836	0.11015	79,731
2038	32	169,566	175,905	25,382	309,142	43,842	723,836	0.10259	74,258
2039	33	169,566	175,905	25,382	309,142	43,842	723,836	0.09554	69,155
2040	34	169,566	175,905	25,382	309,142	43,842	723,836	0.08898	64,407
2041	35	169,566	175,905	25,382	309,142	43,842	723,836	0.08287	59,984
2042	36	169,566	175,905	25,382	309,142	43,842	723,836	0.07718	55,866
2043	37	169,566	175,905	25,382	309,142	43,842	723,836	0.07188	52,029
2044	38	169,566	175,905	25,382	309,142	43,842	723,836	0.06694	48,454
2045	39	169,566	175,905	25,382	309,142	43,842	723,836	0.06234	45,124
2046	40	169,566	175,905	25,382	309,142	43,842	723,836	0.05806	42,026
2047	41	169,566	175,905	25,382	309,142	43,842	723,836	0.05407	39,138
2048	42	169,566	175,905	25,382	309,142	43,842	723,836	0.05036	36,452
2049	43	169,566	175,905	25,382	309,142	43,842	723,836	0.04690	33,948
2050	44	169,566	175,905	25,382	309,142	43,842	723,836	0.04368	31,617
2051	45	169,566	175,905	25,382	309,142	43,842	723,836	0.04068	29,446
2052	46	169,566	175,905	25,382	309,142	43,842	723,836	0.03788	27,419
2053	47	169,566	175,905	25,382	309,142	43,842	723,836	0.03528	25,537
2054	48	169,566	175,905	25,382	309,142	43,842	723,836	0.03286	23,785
2055	49	169,566	175,905	25,382	309,142	43,842	723,836	0.03060	22,149
2056	50	169,566	175,905	25,382	309,142	43,842	723,836	0.02850	20,629
		8,986,998	9,322,963	1,345,245	16,384,526	2,323,625	38,363,296		11,994,147
Total Annual Cost (50 Year Life)								0.07591	910,000

Table D-II-25

Average Annual Equivalent Induced Crop Damage

All Plans of Improvement

Grand Prairie Area Demonstration Project

(October 1996 Price Levels, 7.375% Discount Rate)

Item	Little Lagure Bayou	Mill Bayou
1. Expected Annual Acres		
With-Project	1,037	2,088
Without-Project	957	1,915
Increase	80	173
2. Damage Rate/Acre	$ 46.68	$ 46.68
3. Annual Damage		
With-Project	$ 48,000	$ 97,000
Without-Project	45,000	89,000
Increase	4,000	8,000

Figure D-II-3 shows that a 9.0 foot or greater water depth is available 62.5% of the time under existing conditions. With-project it is reduced to 60.8% of the time, a reduction of approximately 6 days per year. A 10.5 foot or greater water depth which can support fully loaded 9.5 foot barges is currently available only 56.3% of the time. With-project it is reduced to 55.6% of the time, a reduction of less than 3 days per year. Again, these percentages are based on an analysis of the 47 year period of record presented above.

(2) Movements.

(a). Present Movements. The desired monthly movements under present (1996) conditions was estimated using historical (1982 through 1993) information from the USACE Waterborne Commerce Statistics Center and information gained talking to shippers and barge operators. Desired monthly shipments are what the shippers would move each year if sufficient water levels were available in the White River. The prior analysis excluded periods of very low movements due to droughts or floods from the historical data. Even after these periods of very low movements were excluded from the historical data, the resulting desired movements were judged to be low. As shown in the previous paragraphs, a dependable enough channel to move all commodities by water does not currently exist. Therefore, actual movements will almost always be less than desired movements. As expected, the desired shipments out of the White River system are highest during and immediately following soybean and wheat harvest. Receipts coming into the White River system are relatively constant throughout the year.

Only tonnage moving out of or into the White River system was considered in this analysis. All movements between ports on the White River effectively occurred at or upstream of DeValls Bluff, Arkansas. Since the Grand Prairie Demonstration Project will only affect the White River at and below DeValls Bluff, tonnage moving between White River ports but not out of or into the system was excluded. Movements for 1996 were estimated at 664,000 tons which were comprised of 120,000 tons of receipts and 544,000 tons of shipments. The 120,000 tons in receipts consists of 90,000 tons of fertilizer and fertilizer materials (75%) and 30,000 tons of waterway improvement materials and sand and gravel (25%). The 544,000 tons of shipments included 332,000 tons of soybeans (61%), 185,000 tons of wheat (34%), and 27,000 tons of grain sorghum (5%). Estimated 1996 monthly receipts and shipments are shown in Table D-II-26.

Figure D-II-3. Availability of Various Water Depths
White River, Arkansas
(Average of Before and After Dredge Conditions)

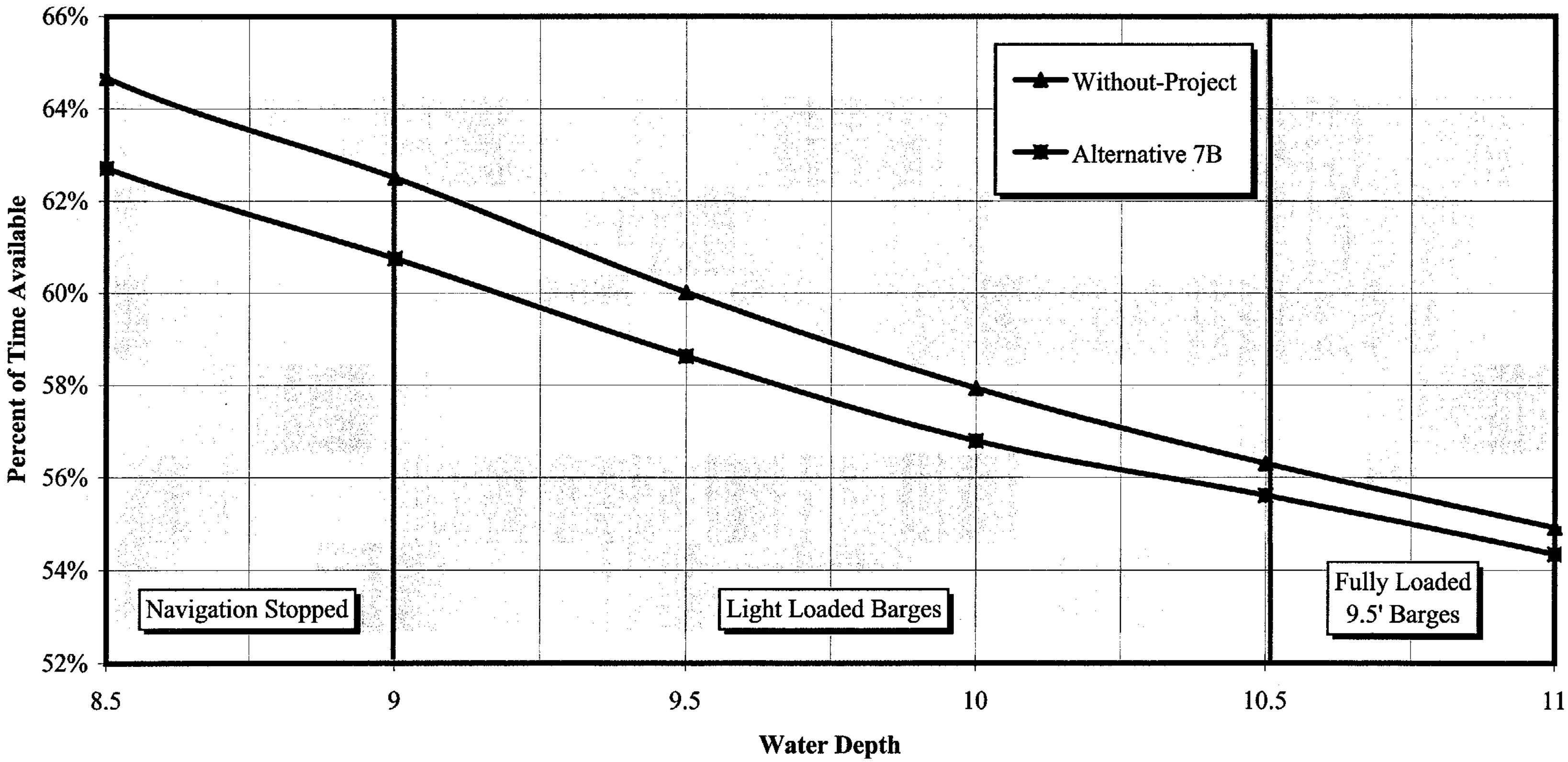

Table D-II-26

Desired Monthly Receipts and Shipments and Maximum Movements

Present and Projections for Future Conditions

White River, Arkansas

Grand Prairie Area Demonstration Project

(tons)

	Maximum	1996			2015			2056		
Month	Movement	Receipts	Shipments	Total	Receipts	Shipments	Total	Receipts	Shipments	Total
January	140,000	14,000	107,000	121,000	15,000	134,000	149,000	18,000	228,000	246,000
February	140,000	10,000	103,000	113,000	11,000	128,000	139,000	13,000	220,000	233,000
March	160,000	10,000	53,000	63,000	11,000	66,000	77,000	13,000	113,000	126,000
April	140,000	9,000	18,000	27,000	10,000	22,000	32,000	11,000	38,000	49,000
May	125,000	14,000	16,000	30,000	15,000	20,000	35,000	18,000	34,000	52,000
June	125,000	20,000	72,000	92,000	21,000	90,000	111,000	24,000	154,000	178,000
July	120,000	16,000	33,000	49,000	17,000	41,000	58,000	20,000	70,000	90,000
August	50,000	10,000	6,000	16,000	11,000	7,000	18,000	13,000	13,000	26,000
September	25,000	5,000	12,000	17,000	5,000	15,000	20,000	6,000	26,000	32,000
October	40,000	6,000	22,000	28,000	6,000	27,000	33,000	8,000	47,000	55,000
November	65,000	3,000	46,000	49,000	3,000	57,000	60,000	4,000	98,000	102,000
December	100,000	3,000	56,000	59,000	3,000	70,000	73,000	4,000	119,000	123,000
Total		120,000	544,000	664,000	128,000	677,000	805,000	152,000	1,160,000	1,312,000

(b). Future Movements. The production of agricultural commodities and the use of agricultural production inputs in the area are expected to increase over time as new technologies, crop varieties, and production practices are developed and adopted by area farmers. A description of the methodology used in projecting future production and future use of production inputs is presented in the Benefit Section of this appendix. Since the majority of the movements on the White River are agricultural crops or production items (96.2%), these movements should also be expected to experience an increase. The only commodity not projected to increase is the receipt of waterway improvement materials, which is held constant. Waterway improvement materials are used primarily for maintenance on the White River and thus should not change significantly baring any large scale changes to the river channel. The increase in tonnage is assumed to be proportional in that the barged share of the commodities is expected to increase proportionally to the share of other transportation modes. All movements of each transportation mode (truck, rail, and barge) are expected to increase at the same rate.

Future movements are also presented in Table D-II-26. Movements are projected to increase 21% to 805,000 tons by 2015 and to 1,312,000 tons by 2056. The shipments of soybeans, wheat, and grain sorghum are projected to increase proportionally thus keeping the percentage of each constant at 61%, 34%, and 5%, respectively. Receipts of waterway improvement materials are held constant at 30,000 tons with all increases in receipts coming from fertilizer and fertilizer materials. Again, tonnage not leaving the White River system is excluded from these movements for the rationale given for present movements.

(c). Maximum Movements. For present (1996) conditions, no more than the historical maximum movement could take place for any one time period. (Example: March's historical maximum movement for the above period of record is 160,000 tons. Therefore, no more than 160,000 tons can be moved during March). Maximum movements were needed to address existing shipping constraints on the White River (i.e., sufficient capacity does not exist to move an entire year's tonnage during a one or two month window). Maximum movements were also needed to keep from minimizing the project's effect on shipping. For example, if the project causes shipping to stop and sufficient barge capacity is not available to move the delayed tonnage, then the potential exists for an increased effect. But if there is no movement limitation then the effect would be minimized by assuming that all delayed tonnage would be moved when navigation resumes. Maximum movements for 1996 are also shown in Table D-II-26. These maximums were allowed to grow proportionately over time along with the expected increase in movements since any significant increase in tonnage would require a corresponding increase in the capacity of the local barge industry.

(3). Cost per Ton of Delays, Diversions, and Light Loadings.

(a). Delays. The effect caused by delays is estimated as the interest associated with not being able to sell the delayed commodities on a timely basis and use the proceeds to either invest or to pay off obligations. The interest rate used in this section is the current Federal discount rate of 7.375 percent. The monthly delay cost for receipts is estimated at $1.40 per ton ($228/ton of fertilizer times 7.375% divided by 12 months). The monthly delay cost for shipments is estimated to be $1.04 per ton (weighted average of $212.50/ton for soybeans, $101.33/ton for wheat, and $99.00/ton for milo times 7.375% divided by 12 months). The prices used for soybeans, wheat, and milo are the FY 1996 Current Normalized Prices used for analyzing water resources projects which are the latest available prices.

(b). Diversions. The added cost of diversions is the added cost of shipping the diverted tonnage by the next least costly means of transportation. In this case the least costly alternative is through an alternate port on a nearby waterway. The closest alternate ports available for the White River are located at Pine Bluff, Arkansas which is on the Arkansas River and Osceola, Arkansas and Memphis, Tennessee which are located on the Mississippi River. The tonnage on the lower White would probably go through Pine Bluff, Arkansas. The tonnage from the middle of the White system would go through Memphis, Tennessee. Osceola, Arkansas would probably move the diversions from the upper White River. The average cost of shipping through these ports is estimated to be $16.83 per ton which is comprised of $6.02 per ton in actual barge rates, $6.22 in trucking costs to the alternate port, and $4.59 in additional handling and shrinkage. The average cost of shipping on the White River is estimated at $7.49 which yields an increase of $9.34 per ton or $0.28 per bushel.

(c). Light Loading. The additional cost per ton due to light loading is the cost of shipping a less than fully loaded barge. The cost per ton of a fully loaded 9.5 foot draft barge on the White River is estimated at $7.49 per ton. The cost per ton of a 9 foot draft is $7.70 yielding a difference of $0.21 per ton. The cost per ton of a 8 foot draft is $8.86 for an increase of $1.37 per ton. Movements of less than an 8 foot barge are not deemed cost effective by the White River shippers and barge operators. Therefore, an 8 foot draft is the lightest loaded barge expected to move on the White River. The increased cost per ton of shipping various drafts of light loaded barges in shown on Figure D-II-4.

Figure D-II-4. Additional Cost Per Ton of Shipping Light Loaded Barges

White River, Arkansas

(October 1996 Price Levels)

(4). Tonnage Affected. The desired monthly movement schedule presented in Table D-II-26 was compared to the 47 year period of record of average weekly water depths for both without- and with-project conditions to determine the effects on tonnage. But before this was done, three assumptions were made which apply to both without- and with-project conditions:

- Soybeans received during the fall and early winter were desired to be moved by the end of May. Any stocks remaining due to unfavorable without- or with-project river conditions would be moved by an alternate mode.
- Wheat received during the late spring and early summer was desired to be moved by the end of September. Any stocks remaining due to unfavorable without- or with-project river conditions would be moved by an alternate mode.
- No more than the historical maximum movement could take place for any one time period. (Example: The March 1996 maximum movement was 160,000 tons. Therefore, no more than 160,000 tons could be moved during March 1996). These maximums were allowed to grow proportionately over time along with the expected increase in movements since any significant increase in tonnage would require a corresponding increase in the capacity of the local barge industry.

(a). Without-Project Conditions. The results of the comparison indicate that navigation is being significantly impaired by low water depths during present day or existing conditions. The desired monthly schedules presented in Table D-II-26 could not be moved during the 47 year period of record. Light loading of some movements would occur during 3 years (6.4% of time) without delays or diversions. During an additional 10 years (21.3% of time) there would be delays of movements along with light loading. For the remaining 34 years (72.3% of time) there would be diversions along with delays and light loading. This further highlights the current difficulty for barge traffic on the White River. Table D-II-27 presents the expected tonnage affected under without-project conditions for 1996, 2015, and 2056.

(b). With-Project Conditions. Table D-II-27 also presents the expected tonnage affected under with-project conditions for 1996, 2015, and 2056. With Alternative 7B there would be no effect for 20 years or 42.6% of the time. There would be 17 years (36.2% of time) of additional light loading and an additional 10 years (21.2% of time) of added diversions, delays, and light loading. The incremental differences (difference between without- and with project) are presented in Table D-II-28. Using the present (1996) effects of Alternative 7B as an example, only 5,700 tons of receipts and 8,400 tons of shipments would be light loaded annually. Similarly, only 5,800 tons receipts and 9,100 tons of shipments would be delayed annually. Only 3,300 tons of receipts and 5,000 tons of shipments would be diverted annually. When compared to the annual receipts and shipments of 608,000 tons under existing conditions, this means that only 37,300 or 6.1% are potentially affected annually by the project. Similar results are also presented for Alternatives 7A, 7C, and 7D. Projections for 2015 and 2056 are also presented in Table D-II-28.

Table D-II-27

Annual Tonnage Affected by Low River Flows

Without- and With-Project

Present and Projections for Future Conditions

White River, Arkansas

Grand Prairie Area Demonstration Project

(tons)

Condition	1996			2015			2056		
	Delayed 1/	Diverted	Light Loaded	Delayed 1/	Diverted	Light Loaded	Delayed 1/	Diverted	Light Loaded
Without-Project	419,100	55,000	68,400	508,100	66,700	82,900	828,100	108,700	135,200
Alternative 7A	433,300	62,800	83,000	524,500	75,700	99,600	857,900	124,900	164,900
Alternative 7B	434,000	63,300	82,500	525,300	76,300	99,100	859,100	125,900	164,100
Alternative 7C	434,700	63,800	82,000	526,100	76,900	98,600	860,300	126,900	163,300
Alternative 7D	435,400	64,300	81,500	526,900	77,500	98,100	861,500	127,900	162,500

1/ Denotes tonnage that is delayed one month (i.e. one ton-month). One ton delayed for one month is counted as one ton. One ton delayed for two months is counted as two tons. One ton delayed for three months is counted as three tons, etc.

Table D-II-28

Annual Tonnage Affected by Project

Incremental Difference Between Without- and With-Project

Present and Projections for Future Conditions

White River, Arkansas

Grand Prairie Area Demonstration Project

(tons)

	1996			2015			2056		
Alternative	Delayed 1/	Diverted	Light Loaded	Delayed 1/	Diverted	Light Loaded	Delayed 1/	Diverted	Light Loaded
Alternative 7A	14,200	7,800	14,600	16,400	9,000	16,700	29,800	16,200	29,700
Alternative 7B	14,900	8,300	14,100	17,200	9,600	16,200	31,000	17,200	28,900
Alternative 7C	15,600	8,800	13,600	18,000	10,200	15,700	32,200	18,200	28,100
Alternative 7D	16,300	9,300	13,100	18,800	10,800	15,200	33,400	19,200	27,300

1/ Denotes tonnage that is delayed one month (i.e. one ton-month). One ton delayed for one month is counted as one ton. One ton delayed for two months is counted as two tons. One ton delayed for three months is counted as three tons, etc.

(5) Monetary Impacts. The cost per ton figures presented in the preceding paragraphs and Figure D-II-3 were applied to the affected tonnage presented in Table D-II-28 to obtain the effects for the years 1996, 2015, and 2056. These values were then discounted to the end of 2007 using standard discounting practices, the current fiscal year interest rate of 7.375%, and amortized over a 50 year project life. The effects are based on current or October 1996 price levels. Alternative 7B yields average annual equivalent navigation impacts of $127,000. Navigation impacts for these years and the average annual equivalent effects for all of the alternatives are presented in Table D-II-29.

f. Total Annual Costs. Total project first costs for Alternative 7B are $270,512,000. Federal costs account for $175,833,000 with Non-Federal costs making up the remaining $94,679,000 based on 65% Federal and 35% Non-Federal cost sharing. Annual interest charges are $23,781,000 and annual sinking fund charges are $697,000. Alternative 7B also requires annual operation and maintenance of $4,639,000 and causes annual effects to navigation of $127,000 and annual crop damage of $12,000. Total annual costs for Alternative 7B are estimated at $29,256,000. Annual costs for all alternatives are presented in Table D-II-30.

D-II-9. SUMMARY.

Table D-II-31 shows that Alternative 7B is the plan that maximizes net economic benefits (NED plan). Its annual benefits exceed annual costs by $6,876,000 yielding a benefit to cost ratio of 1.2 to 1. All other plans are also economically justified and are presented in Table D-II-31. All four alternatives are justified on their primary (irrigation) benefits alone. Benefits such as waterfowl benefits that occur on privately owned lands have recently received much scrutiny. For this reason it is important to note that all alternatives have excess benefits over costs of greater than $6 million and benefit-to-cost ratios greater that 1.2 to one based solely irrigation benefits. Alternative 7B also maximizes net or excess primary benefits at $6,403,000.

Table D-II-29

Annual Impacts to Navigation by Project

Present and Projections for Future Conditions

White River, Arkansas

Grand Prairie Area Demonstration Project

(October 1996 Price Levels)

Alternative	1996	2015	2056	Average Annual @ 7.375%
	($)	($)	($)	($)
Alternative 7A	95,800	110,800	198,300	121,000
Alternative 7B	100,500	116,300	208,100	127,000
Alternative 7C	107,000	121,800	216,300	132,000
Alternative 7D	110,200	125,500	222,900	136,000

Table D-II-30

Summary of Average Annual Equivalent Costs

Grand Prairie Area Demonstration Project

(October 1996 Price Levels, 7.375% Discount Rate)

Alternative	Interest	Sinking Fund	Operation, Maintenance, and Replacement	Induced Crop Damage	Navigation Impacts	Total
	($)	($)	($)	($)	($)	($)
Alternative 7A	23,218,000	680,000	4,481,000	12,000	121,000	28,512,000
Alternative 7B	23,781,000	697,000	4,639,000	12,000	127,000	29,256,000
Alternative 7C	24,344,000	713,000	4,773,000	12,000	132,000	29,974,000
Alternative 7D	24,907,000	729,000	4,905,000	12,000	136,000	30,689,000

Table D-II-31

Summary of First Costs and Average Annual Equivalent Benefits, Costs, Excess Benefits, and Benefit to Cost Ratios

Grand Prairie Area Demonstration Project

(October 1996 Price Levels, 7.375% Discount Rate)

Item	Alternative 7A	Alternative 7B	Alternative 7C	Alternative 7D
	($)	($)	($)	($)
First Cost				
Import System	195,419,000	201,928,000	208,438,000	214,947,000
On-Farm	68,584,000	68,584,000	68,584,000	68,584,000
Total	264,003,000	270,512,000	277,022,000	283,531,000
Annual Benefits				
Irrigation Benefits	34,823,000	35,659,000	36,266,000	36,844,000
Waterfowl Benefits	467,000	473,000	478,000	487,000
Total	35,290,000	36,132,000	36,744,000	37,331,000
Annual Costs				
Interest				
On-Farm	6,325,000	6,325,000	6,325,000	6,325,000
Import System	16,893,000	17,456,000	18,019,000	18,582,000
Sinking Fund				
On-Farm	185,000	185,000	185,000	185,000
Import System	495,000	512,000	528,000	544,000
Operation and Maintenance				
On-Farm	910,000	910,000	910,000	910,000
Import System				
Pump Station	2,982,000	3,130,000	3,256,000	3,382,000
Small Pump Stations	340,000	348,000	354,000	359,000
Structures	207,000	209,000	211,000	212,000
Channels and Canals	42,000	42,000	42,000	42,000
Navigation Impacts	121,000	127,000	132,000	136,000
Induced Flooding	12,000	12,000	12,000	12,000
Total	28,512,000	29,256,000	29,974,000	30,689,000
Excess Benefits				
Irrigation Benefits Only	6,311,000	6,403,000	6,292,000	6,155,000
All Benefits	6,778,000	6,876,000	6,770,000	6,642,000
BCR				
Irrigation Benefits Only	1.2	1.2	1.2	1.2
All Benefits	1.2	1.2	1.2	1.2

D-II-10. OPTIMIZATION.

a. On-Farm Features. The optimization of the on-farm features is presented in Section III of this appendix. The conservation features were optimized by NRCS and are documented in the NRCS Appendix. The level of on-farm storage reservoirs was determined through a joint effort between NRCS and the Memphis District. The optimum levels of these features was used in this section in the optimization of the import system.

b. Import System. The optimization of the import system is documented in this section of the Economic Appendix. It is optimized from two standpoints. The first is the project's capability to supply an average year's unmet demand. The features associated with the 1,640 CFS system are the minimum required to meet an average year's unmet demand based on hydrologic modeling of supplying the average year's demand with unlimited flows from the White River. The second is optimization from an economic standpoint which examines the trade-offs associated with meeting the un-met crop demands with limited flows in the White River. This was accomplished using detailed hydrologic and economic modeling of the historical un-met demands and flows in the river. The previous paragraphs in this section describe the process of meeting a 47 year period of record demand with the limited supply from the White River. The results of this process establish that the 1,640 CFS system is the optimum based on both supplying unmet demands and economic tradeoffs.

The optimum operation plan of the import system from meeting demands and economic tradeoffs is the one which allows maximum withdrawals from the White River as shown in Section III of this appendix. This plan cannot be implemented due to the institutional constraints of current Arkansas state law regulating withdrawals from the White River. Arkansas State law sets the lower limit for withdrawals. This is an institutional or legal limit that cannot be changed without a change in current law. For this reason, the operating plan that limits withdrawals to the Arkansas State Water Plan was used in the optimization of the import system. Operating plans that further limit withdrawals over the Arkansas State Water Plan, reduce the project benefits greater than any reductions of potential adverse impacts or costs and are not recommended for adoption. However, plans that increase withdrawals, increase the project benefits more than the potential adverse impacts or costs but cannot be adopted. The trade-offs associated with various withdrawal levels are presented in Section III of this appendix.

D-II-11. SENSITIVITY.

Three areas of sensitivity were identified which could affect the economic benefit of the project: (1) participation in the on-farm portion of the project, (2) implementation of additional on-farm conservation features under future without-project conditions, and (3) participation in the total project by the local farmers and landowners. These are addressed in the following.

a. On-Farm Participation Rate. A sensitivity analysis was conducted to assess the effects on the project's economic justification of differing participation rates in the on-farm portion of the project. The concern is that area landowners may be unable or unwilling to make the investments or changes in their farming operations necessary for the on-farm component to provide the economic benefit as presently designed. There is certainly an economic incentive for individual landowners to participate since they will not be able to reduce their demand for irrigation water if they do not participate. Larger portions of their cropland would be forced to convert to dryland practices causing significant economic losses. However, not all landowners will have to participate for the project to provide the level of economic benefit presently estimated. Some may already have sufficient land treatment practices in place. The project only needs enough participation to increase irrigation efficiencies from 60% to 70%. Some landowners may opt for even higher efficiencies. Only an average of 70% must be achieved for the project to accrue the expected benefit.

A range of participation rates from zero to 100% was considered. The annual costs decrease along with the annual benefits as the participation rate decreases. The results of the sensitivity analysis are presented in Table D-II-32. The project is economically justified over the entire range with benefit-to-cost ratios of 1.13 at zero percent participation to 1.24 at 100% participation.

b. Future Without-Project Conservation. A sensitivity analysis was also conducted to assess the effects of increased efficiency levels under future without-project conditions. Interviews of area farmers and landowners by NRCS personnel revealed a strong resistance to the construction of additional conservation measures absent additional sources of irrigation water and any cost sharing incentives. Construction of additional measures on the 54,600 irrigated acres remaining after 2015 would require approximately $18,100,000 while yielding enough additional water to irrigate only 9,100 new acres. A capital investment of $18 million would be almost impossible during a time when farmers are undergoing radical financial changes as their aquifers are exhausted and they are forced to convert to less profitable dryland practices.

Cost sharing for these measures could possibly be available through existing NRCS programs. However, NRCS's budgets are limited and the Grand Prairie area would face stiff competition with other areas these limited funds. Because the Grand Prairie area's current conservation level of 60% is higher than most other areas in the State, the NRCS would likely invest in other less efficient areas which would yield higher rates of return on their expenditures. Absent NRCS cost sharing, any new investment would have to be financed entirely by area farmers and landowners. Since their farming operations will be much less profitable and significantly more risky, lending institutions would be much less willing to underwrite these investments. Because of these obstacles, implementation of new conservation measures was considered highly unlikely under future without-project conditions.

Table D-II-32

Annual Benefits, Costs, Excess Benefits, and Benefit to Cost Ratios

Various Levels of Participation in the On-Farm Portion of Project

Grand Prairie Demonstration Project

(October 1996 Price Levels, 7.375% Discount Rate, $000)

Level of Participation	Annual Benefit	Annual Cost	Excess Benefit	Benefit to Cost Ratio
100%	36,132	29,256	6,876	1.24
90%	35,376	28,846	6,530	1.23
80%	34,611	28,437	6,174	1.22
70%	33,836	28,027	5,809	1.21
60%	33,055	27,617	5,438	1.20
50%	32,270	27,208	5,062	1.19
40%	31,484	26,798	4,686	1.17
30%	30,701	26,388	4,313	1.16
20%	29,915	25,978	3,937	1.15
10%	29,131	25,569	3,562	1.14
0%	28,345	25,159	3,186	1.13

A sensitivity analysis was performed to address the possibility of more conservation features being built, assuming that funding the above conservation features could be obtained. It was further assumed that these features would be built starting in 2001 and completed by 2015. Including these features in the future without-project condition would reduce the annual benefits by \$3,405,000 resulting in benefits of \$32,727,000 annually. An accompanying annual cost decrease would occur since desired conservation levels would have already been reached on approximately 26 percent of the project area. This would result in an annual cost of \$28,176,000, a decrease of \$1,080,000, a benefit to cost ratio of 1.2 and excess benefits of \$4,551,000.

c. Participation in Total Project. A sensitivity analysis was conducted to assess the effects on the project's economic justification of differing participation rates in the total project by the local farmers and landowners. The concern is that they may be unable or unwilling to participate in what is seen by some as a voluntary project. If they do not participate, the project may be unable to deliver the economic benefit as presently designed. Again, the economic incentive exists for them to participate since larger portions of their cropland would be forced to convert to dryland practices causing significant economic losses. However, not all landowners will have to participate for the project to be a sound investment. A range of participation rates from 60% to 100% was considered. The annual costs decrease along with the annual benefits as the participation rate drops. The results of the sensitivity analysis are presented in Table D-II-33. The project is economically justified at a participation rate at or over 63.6%. At 63.6% the project has a unity benefit to cost ratio.

For this section several assumptions were made. If individual farmers or landowners would not participate in the project in any way their on-farm costs would be excluded from the project. Also no water sales would be made to the non-participators so no benefit was claimed on their lands. If possible their imported irrigation water would be sold to others in the project during "dry" years and a benefit claimed. However, during "wet"years their water would remain unsold and no benefit would be claimed. If their water was unsold then the operation and maintenance costs for the import system would also be reduced since the water would not be pumped. The import system size was held constant to service the whole project area's needs so the import system interest and sinking fund costs remained unchanged.

Table D-II-33

Annual Benefits, Costs, Excess Benefits, and Benefit to Cost Ratios

Various Levels of Participation in the Total Project

Grand Prairie Demonstration Project

(October 1996 Price Levels, 7.375% Discount Rate, $000)

Level of Participation	Annual Benefit	Annual Cost	Excess Benefit	Benefit to Cost Ratio
100%	36,132	29,256	6,876	1.24
95%	34,916	28,873	6,043	1.21
90%	33,718	28,495	5,223	1.18
85%	32,491	28,108	4,383	1.16
80%	31,136	27,680	3,456	1.12
75%	29,678	27,220	2,458	1.09
70%	28,180	26,748	1,432	1.05
65%	26,590	26,247	343	1.01
60%	24,878	25,707	-829	0.97

SECTION III

OPTIMIZATION OF ON-FARM FEATURES AND WHITE RIVER WITHDRAWALS

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SECTION III - OPTIMIZATION OF ON-FARM FEATURES AND WHITE RIVER WITHDRAWALS

D-III-1. INTRODUCTION.

This section of the Economic Appendix presents information pertaining to the optimization and economic evaluation of the on-farm features and White River withdrawals for the Grand Prairie Area Demonstration Project. It is based on supplying irrigation water to a 267,300 acre irrigated area in Arkansas, Monroe, and Prairie counties in eastern Arkansas. This area is described in a later section. These features were optimized on both an individual farm and a system-wide basis. The on-farm features were assessed by surveying individual farms to determine existing conservation practices, storage reservoirs, recovery systems, cropping practices, water sources, and water uses. These data were used as the starting point with which to determine any potentials for increasing the existing features and achieving greater conservation levels. The individual data was then combined to determine the without- and with-project system wide demands to assess the effects of potential with-project withdrawals from the White River.

D-III-2. GENERAL.

The Information and computations presented in this section describe the methodology used in determining benefits for the various benefit categories under existing and future conditions. The evaluation required a determination of current (FY 1995) agricultural land use. Current agricultural land use was based on a complete survey of the area conducted by the US Department of Agriculture, Natural Resources Conservation Service (NRCS). The survey was a compilation of the historical records maintained by each county's Farm Service Agency's office. It also required a projection of future with- and without-project conditions throughout the project life.

The price level of the benefits and costs is October 1995. The costs of individual construction items are assumed to be end of the year values. The project construction period is from 2001 to 2013. The benefits associated with each item are assumed to occur 1 year after the item's completion. The reference point for calculating present values of benefits and costs is the beginning of 2014, the first year after project completion. All costs and benefits prior to 2014 are compounded forward and all costs and benefits after 2014 are discounted backward at a discount rate of 7.75 percent. The total present values are amortized over a 50 year project life to obtain average annual equivalent benefits and costs. Benefits accruing to each alternative are described in terms of three general categories:

(a) Irrigation benefits
(b) NED employment benefits
(c) Fish and wildlife benefits

D-III-3. AREA DESCRIPTION.

The area that would benefit from project construction consists of approximately 394,000 acres located in Arkansas, Lonoke, Monroe, and Prairie Counties in Arkansas. The area is predominately agricultural with scattered rural development. A total of 267,300 acres is cleared, in agricultural production and subject to irrigation in any one year. This acreage consists of 264,200 acres of cropland and 3,100 acres of fish ponds. However, it does not include the approximately 9,790 acres of single-cropped soybeans. These 9,790 acres are currently planned to be converted to new on-farm reservoirs under with-project conditions. They were excluded from the without- to with-project comparisons to better facilitate a direct comparison of the two during the benefit analysis. Approximately 94 percent of the cropland is irrigated during any one year. The remaining 6 percent of cropland not irrigated is usually due to farm programs or ongoing improvement operations such as land leveling. However, recent changes in farm programs and government subsidies will probably reduce the acreage idled during any one year. For this reason, the without- and with-project comparisons were conducted under the assumption that all of the area will be irrigated during an average year.

D-III-4. PLANS OF IMPROVEMENT.

The following is a presentation of the alternatives that were carried through an economic (benefit to cost) analyses for the optimization of the on-farm features and White River Withdrawals. Many plans were screened or eliminated before they reached an economic evaluation due to various factors. The screening process and a complete listing of all of the alternatives, including those not carried into detailed economic analysis can be found in the main report section. These plans range from no improvements to stand alone features to combinations of the stand alone features. All of these plans are designed to take advantage of all existing sources of irrigation water in addition to water that they can potentially supply. These existing sources include groundwater, on-farm storage reservoirs, rainfall capture, and tailwater recovery (recycling of irrigation water).

a. Alternative 1A. Alternative 1A is the no action alternative. It is the set of conditions expected to occur in the absence of a project. The supply of irrigation water is expected to decrease substantially as the area's groundwater resource is depleted. Historical trends, reaffirmed by current well data and field observations by NRCS and local farmers in conjunction with results of extensive groundwater modeling studies show that approximately 22% of the project area can be irrigated during an average year after the aquifer is depleted. However, before the aquifer is completely exhausted it is likely that the state of Arkansas will designate the grand prairie area as a "critical groundwater area" at which point withdrawals would likely be limited to the annual recharge rate. Legal and institutional restrictions would then become the governing factor instead of physical constraints. Regardless of whether the physical or legal constraints govern, only 22% of the project area would be irrigated for future without-project conditions. The main difference between the two limitations is the timing or year in which they would occur. For the purpose of this economic analysis it was assumed that the physical constraint would be the most likely which would have the aquifer depleted (only yielding recharge capacity) by the year 2015. If the legal constraint occurs first future without-project projections would be worse than what is presented in this economic analysis. Because of this it should be noted that future without-project conditions are presented in the most favorable light for without-project irrigation and in the least favorable light for estimation of with-project benefits.

b. Alternative 3A. Alternative 3A consists of conservation measures without an import system. Conservation, measures would be implemented to maximize the use of existing water sources to the extent practical. These measures are designed to increase the efficiency or usage of irrigation water, from 60 percent to 70 percent. The current efficiency rate of 60 percent would be increased to 70 percent through the installation of conservation measures designed to minimize losses, recycle or reuse water through tailwater recovery systems, and construction of on-farm storage reservoirs. With this alternative, the availability of existing runoff for capture would limit new reservoir construction to approximately 1,400 acres with conservation measures placed on approximately 31 percent of the area's current irrigated acreage. This means that when groundwater is depleted or regulated at the safe (recharge) yield only about 31 percent of the area could remain in irrigation in the absence of some form of supplemental source of irrigation water. The remainder of the area would change to dryland agriculture. The 70 percent conservation level was identified by NRCS as the optimum or most efficient level and is documented in the NRCS Appendix of this report. This section will not duplicate NRCS's findings but will present the benefits and costs associated with the 70 percent level to show that it is economically viable and to present its trade-offs with the other alternatives evaluated in this section.

c. Alternative 5A. Alternative 5A consists of a combination of the conservation measures in Alternative 3, on-farm storage reservoirs capable of providing approximately 25 percent of existing irrigation needs or 30 percent of with-project needs when reduced by conservation measures, and an 1,800 cfs import system. Again, conservation measures are designed to achieve the optimum level by increasing the irrigation efficiencies from 60% to 70% for the project area. On-farm storage is used to capture existing runoff and to store import water for use during peak demand periods or when other sources cannot provide the need. The import system provides irrigation water from excess flows in the White River to the farms through a network of new canals, pipelines, and existing streams. In most instances new canals would be constructed on higher ground in the area so that the irrigation water could gravity feed to the fields, thus reducing on-farm pumping costs. These three components cannot be viewed as independent or stand-alone features. They are related and are dependent on each other to function properly.

Alternative 5A requires 9.790 acres of additional on-farm storage supplying 97,900 acre-feet. Alternative 5A was further analyzed at various stop-pump levels or withdrawal limitations on the White River to demonstrate that the most efficient level was identified. These withdrawal or stop-pump levels include the current Arkansas State Water Plan (variable rate) and the following flows measured in cubic feet per minute (CFS): 5,250; 7,125; 9,650; 11,350; 12,850; and 17,500 CFS. The stop-pump or residual flows in the White River in conjunction with this alternative are as follows:

Alternative 5A(1) -- 5,250 CFS residual flow
Alternative 5A(2) -- 7,125 CFS residual flow

Alternative 5A(3) -- 9,650 CFS residual flow
Alternative 5A(4) -- 11,350 CFS residual flow
Alternative 5A(5) -- 12,850 CFS residual flow
Alternative 5A(6) -- Current Arkansas State Water Plan
Alternative 5A(7) -- 17,500 CFS residual flow

d. Alternative 6A. Alternative 6A consists of the conservation features and 1,800 cfs import system in Alternative 5A above. The difference is that the new on-farm storage reservoirs are increased an additional 25 percent. Alternative 6A requires 12,238 acres of additional on-farm storage supplying 122,380 acre-feet. Alternative 6A was analyzed for the same array of stop-pump scenarios as Alternative 5A and designated as follows:

Alternative 6A(1) -- 5,250 CFS residual flow
Alternative 6A(2) -- 7,125 CFS residual flow
Alternative 6A(3) -- 9,650 CFS residual flow
Alternative 6A(4) -- 11,350 CFS residual flow
Alternative 6A(5) -- 12,850 CFS residual flow
Alternative 6A(6) -- Current Arkansas State Water Plan
Alternative 6A(7) -- 17,500 CFS residual flow

D-III-5. WITHOUT-PROJECT CONDITIONS.

a. Present Conditions. The first step in defining present (1995) conditions was to determine existing land use. This was done in conjunction with the National Resource Conservation Service (NRCS). A GIS of the area's Farm Service Agency's records was developed consisting of data broken down to the farm tract level showing the acreage of individual crops on each tract. This data revealed that all of the tracts suitable for irrigation were currently irrigated. There are 267,300 acres subject to irrigation in the study area. This figure does not include 9,790 acres of single-cropped soybeans on which the planned on-farm storage reservoirs will be constructed. This omission was made in order to facilitate a direct comparison between without- and with-project conditions. Approximately 94% of this area is irrigated in any given year. The remainder is usually idled by farm programs or by the need to install land treatment measures such as land leveling or tailwater recovery measures. Soybeans account for 56.4% (87,706 acres single-cropped and 62,977 acres double-cropped with wheat) of the total. Rice follows at 36.3% (97,076 acres), milo at 3.5% (9,310 acres), corn at 2.6% (7,110 acres), and aquaculture at 1.2% (3,101 acres).

Agriculture uses 536,900 acre-feet of irrigation water during an average year. Rice is the heaviest user at 46.6% or 250,300 acre-feet. Soybeans follow closely at 45.1% or 242,000 acre-feet. All other uses amount to only 44,600 acre-feet or 8.3%. The majority of the water used in the area comes from the area's alluvial aquifer. Groundwater accounts for 85.7% or 460,200 acre-feet of total use. This figure includes 417,200 acre-feet of direct use and 43,000 acre-feet recycled through tailwater recovery. The remaining 14.3% or 76,700 acre-feet come from on-farm storage reservoirs which are filled during non-crop seasons (69,500 acre-feet) and its recycling through tailwater recovery systems (7,200 acre-feet).

NRCS combined the above data with the crop's daily water requirements, in-season rainfall data, and evaporation/transpiration data to conduct a water balance analysis for the 18 year period of 1965-82. The result of the analysis was an average ten day water requirement, unmet by rainfall, for each year of the period of record. Ten day periods were used since this time period corresponds to the wilting point of the crops, the point at which yield reductions occur unless supplemental water is applied. The resulting demand is the demand for water that must come from other sources such as groundwater or storage reservoirs (the demand unmet by rainfall). NRCS then compared the seasonal demand for irrigation water with the seasonal availability of rainfall, groundwater, water from storage reservoirs, and tailwater recovery to determine the amount of irrigation water supplied from each source and determine the volume of water that must come from outside sources as groundwater is depleted. A description of the water balance analysis is presented in the NRCS portion of this report. The 18 year period was subsequently expanded by the Memphis District utilizing regression analysis of the years 1940-86 to yield a 47 year sample which was felt to be more reliable and representative of the area conditions. This period was desired because the Little Rock District had an existing synthetic period of record for flows on the White River for this time span which could be used to determine the availability of import water under with-project conditions. Lengthening to 47 from 18 years greatly enhances the statistical significance and the reliability of the results of the demand/supply analysis.

The above regression analysis correlated the demands developed by NRCS with rainfall, temperature, and evaporation/transpiration data for the years 1965-82 to extend the period used to estimate the demand for irrigation water. The resulting relationship was then applied to the remaining years to extend the period to 1940-86. The actual data developed by NRCS for the years 1965-82 was used in conjunction with the results of the regression model for the 1940-81 and 1983-86 periods. The resulting period of record for demand was input into a supply model developed by the Memphis District Hydraulics Branch in conjunction with HEC in Davis, California. A description of this model is presented in the Hydraulics Appendix. A comparison of the yearly demand and supply data revealed that all demands could not be satisfied with the import system alone. In order to meet all demands, substantial amounts of groundwater were required which resulted in significant annual depletion of the alluvial aquifer even with the project. However, the project would still offset a significant portion of the lost groundwater and would extend the number of years that all needs could be met thereby prolonging the life of the aquifer.

The final step was to estimate the net value of the area's agricultural production. This was done by developing crop practices, budgets, and yields for the area from data supplied by NRCS, University of Arkansas Extension Service, and interviews with area farmers. All data was adjusted as necessary to better reflect local conditions when necessary. This data was applied to the number of acres of irrigated cropland and fish ponds in the project area resulting in the value of the area's contribution to the national economy. Table D-III-1 contains the data compiled for this section.

b. Future Without-Project Conditions. Under future without-project conditions the desired land use and demand for irrigation water was the same as for present conditions. Irrigated cropland and fish ponds would remain at 267,300 acres and water use would remain at 536,900 acre-feet if sufficient irrigation water was available. Crop budgets and yields were projected using traditional methods employed by the Memphis District. The difference between present and future without-project conditions is the availability of groundwater. The supply of groundwater is expected to be significantly reduced as the aquifer is depleted. This is backed up by a University of Arkansas study for the Memphis District during the feasibility phase of this study and reaffirmed by field observations of current conditions by NRCS field personnel, local farmers, and a subsequent study by the University of Memphis Groundwater Institute. Since a significant amount of groundwater is expected to be lost, a significant acreage must shift to dryland farming practices, which would result in substantially reduced agricultural production in the project area.

(1). Supply of Irrigation Water. Considerable uncertainty exists when estimating the point at which the aquifer will be depleted and its effective yield limited to its recharge rate. If a series of "wet" years occurs with excessive rainfall, this point could be pushed farther into the future. If a series of "dry" years occur with minimal rainfall, this point could be swiftly accelerated. However, well before the aquifer is completely depleted the State of Arkansas will probably declare the Grand Prairie Area a critical water shortage area. At this point the State could begin limiting withdrawals at levels close to the recharge rate to prevent permanent damage of the aquifer. Therefore, the recharge rate will probably become the limiting groundwater factor several years before the aquifer is depleted due to political or institutional instead of physical constraints.

The supply of irrigation water is expected to shrink considerably in the near future as shown in Table D-III-2. Existing on-farm storage reservoirs and in-season recovery of irrigation water and rainfall are projected to remain unchanged since they are already effectively optimized. The decrease will come from groundwater as the area's aquifer is exhausted. By the turn of the century available irrigation water is estimated to be down by 147,800 acre-feet, a 28% reduction. By 2015 the groundwater yield is expected to approach its recharge level of 38,600 acre-feet per year. The total shortfall at 2015 is estimated to be 378,600 acre-feet, a 71% reduction.

Table D-III-1

Present (1995) Land Use

Grand Prairie Area Demonstration Project

(October 1995 Price Levels)

Item	Percent Dist.	Acres 1/	Water Used	Unit	Price	Yield	Gross Revenues	Production Cost 2/	Net Return	Weighted Net Return
			(ac-ft)		($)		($)	($)	($)	($)
Rice	36.3%	97,076	250,300	bu.	7.15	145	467	362.60	103.94	37.75
Soybeans	32.8%	87,706	155,300	bu.	5.95	45	268	219.50	48.25	15.83
Double-Crop	23.6%	62,977					375	339.34	35.46	8.36
Soybeans			86,700	bu.	5.95	40				
Wheat			0	bu.	3.04	45				
Grain Sorghum	3.5%	9,310	15,500	cwt.	4.05	70	284	257.11	26.39	0.92
Corn	2.6%	7,110	14,600	bu.	2.48	175	434	316.00	118.00	3.02
Aquaculture	1.2%	3,101	14,500	lb.	0.7936	4,750	3,770	2,780.46	989.14	11.48
Total	100.0%	267,280	536,900							77.35

1/ Cleared acres subject to irrigation.

2/ Excludes charges for land and management.

Table D-III-2
Present (1995) and Projected Demand and Supply for Irrigation Water
Without-Project Conditions
Grand Prairie Area Demonstration Project
(Acre-Feet)

Item	Year						
	1995	2000	2005	2010	2014	2015	2063
Demand	536,900	536,900	536,900	536,900	536,900	536,900	536,900
Supply							
Groundwater	417,200	174,700	129,300	84,000	47,700	38,600	38,600
Storage Reservoirs	69,500	69,500	69,500	69,500	69,500	69,500	69,500
Tailwater Recovery	50,200	25,200	21,600	17,900	15,000	14,300	14,300
Total	536,900	269,400	220,400	171,400	132,200	122,400	122,400
Shortfall	0	267,500	316,500	365,500	404,700	414,500	414,500

(2). Acres of Irrigated Crops. The reduction in available irrigation water translates into a substantial reduction in irrigated acreage. By 2000 the acreage of irrigated crops is expected to be down to 193,700, a 28% reduction. Approximately 193,700 acres should be shifted to dryland farming practices. Soybeans will make up the majority (94%) of the dryland crops with 51,500 acres single cropped and 17,500 double cropped with wheat. The remainder will be comprised of grain sorghum at 2,600 acres and corn at 2,000. By 2015 irrigated crops are projected to be down to 71,800 acres, a 73% reduction. The remaining 195,500 acres will also be shifted to dryland practices which will be comprised of 136,700 acres of single cropped soybeans, 46,600 acres of double cropped soybeans, 6,900 acres of grain sorghum, and 5,300 acres of corn. Projected without-project land use by crop is presented in Table D-III-3 for both irrigated and dryland crops.

It is recognized that the area farmers may chose to partially irrigate their crops instead of a true or complete shift to dryland practices as their existing water sources are depleted. This is not viewed as the "best" or optimum use of their water resources. Net farm income over the project life would be maximized by fully irrigating all of the acreage that their water sources can supply with a shift of the remaining acreage to dryland crops. For this reason, a shift to dryland practices instead of partial irrigation was chosen as the most likely future without-project condition.

(3). Crop Data. The calculation of future crop budgets was accomplished by projecting both crop yields per acre and levels of crop production inputs per acre. The price levels for both crops and production costs were held constant at 1995 price levels. The methodology used to project crop yields and levels of production inputs is consistent with that used for other Memphis District studies. A first degree polynomial function was fit to crop budget input and output indices published by the Economic Research Service of the U.S. Department of Agriculture. The resulting regression equations and indexes are presented in Table D-III- 4. The correlation coefficients for the output and input equations were .94873 and .37086, respectively. The output equation tested statistically significant at the 1 percent level of significance, while the input equation tested significant at the 2 percent level. The indexes were applied to the present (1995) values in Tables D-III-5 and D-III-6 to yield the future values used in this analysis. Projected without-project crop data for irrigated crops is presented in Table D-III-5. Projected without-project crop data for dryland crops is presented in Table D-III-6.

(4). Present and Future Net Revenue. Total net revenue or net farm income begins to decrease substantially from the current level of $20.7 million by the turn of the century as groundwater is exhausted. By the year 2000 net farm income has dropped to $12.3 million dollars. By 2015 net farm income has decreased to $9.3 million. Rice and soybeans are the major contributors to net farm income at $10.1 million and $6.4 million, respectively followed by aquaculture at $3.1 million. Net farm income under without-project conditions is presented in Table D-III-7 for the period 1995 through 2063.

Table D-III-3

Present (1995) and Projected Land Use

Without-Project Conditions

Grand Prairie Area Demonstration Project

(Acres)

Item	Year						
	1995	2000	2005	2010	2014	2015	2063
Irrigated Cropland							
Rice	97,100	55,600	44,500	33,500	24,600	22,400	22,400
Soybeans Single-Cropped	87,700	50,200	40,200	30,200	22,200	20,200	20,200
Soybeans Double-Cropped	63,000	36,100	28,900	21,700	15,900	14,500	14,500
Grain Sorghum	9,300	5,300	4,200	3,200	2,300	2,100	2,100
Corn	7,100	4,100	3,300	2,400	1,800	1,600	1,600
Aquaculture	3,100	1,800	1,400	1,100	800	700	700
Total	267,300	153,100	122,500	92,100	67,600	61,500	61,500
Dryland Cropland							
Soybeans Single-Cropped	0	80,300	101,800	123,100	140,300	144,600	144,600
Soybeans Double-Cropped	0	26,900	34,100	41,300	47,100	48,500	48,500
Grain Sorghum	0	4,000	5,100	6,100	7,000	7,200	7,200
Corn	0	3,000	3,800	4,700	5,300	5,500	5,500
Total	0	114,200	144,800	175,200	199,700	205,800	205,800
Total Cropland	267,300	267,300	267,300	267,300	267,300	267,300	267,300

Table D-III-4
Projection Factors for Crop Yields and Production Inputs
Grand Prairie Area Demonstration Project

Item	Equation	Year						
		1995	2000	2005	2010	2014	2015	2063
Crop Yields	y = 0.0167348X - 32.4349327	1.00	1.06	1.12	1.18	1.23	1.25	2.11
Production Inputs	y = 0.0051037X - 9.1882495	1.00	1.02	1.04	1.07	1.09	1.09	1.34

Table D-III-5
Present (1995) and Projected Crop Yields, Gross Returns, Production Costs, and Net Returns per Acre
Irrigated Crops, Without-Project Conditions
Grand Prairie Area Demonstration Project
(October 1995 Price Levels)

	Year						
Item	1995	2000	2005	2010	2014	2015	2063
Rice							
Yield (bu)	145.0	153.18	162.31	171.44	178.74	180.57	306.47
Price ($/cwt)	7.15	7.15	7.15	7.15	7.15	7.15	7.15
Gross Return ($)	466.54	492.86	522.23	551.61	575.10	580.98	986.07
Production Cost ($)	362.60	370.56	378.87	387.17	393.82	395.48	487.30
Net Return ($)	103.94	122.30	143.36	164.44	181.28	185.50	498.77
Soybeans Single-Cropped							
Yield (bu)	45.00	47.54	50.37	53.21	55.47	56.04	95.11
Price ($/bu)	5.95	5.95	5.95	5.95	5.95	5.95	5.95
Gross Return ($)	267.75	282.86	299.70	316.60	330.05	333.44	565.90
Production Cost ($)	219.50	224.32	229.35	234.38	238.40	239.41	294.99
Net Return ($)	48.25	58.54	70.35	82.22	91.65	94.03	270.91
Soybeans Double-Cropped							
Wheat							
Yield (bu)	45.00	47.54	50.37	53.21	55.47	56.04	95.11
Price ($/bu)	3.04	3.04	3.04	3.04	3.04	3.04	3.04
Soybeans							
Yield (bu)	40.00	42.26	44.78	47.29	49.31	49.81	84.55
Price ($/bu)	5.95	5.95	5.95	5.95	5.95	5.95	5.95
Gross Return ($)	374.80	395.97	419.57	443.13	462.02	466.73	792.21
Production Cost ($)	339.34	346.79	354.57	362.34	368.56	370.12	456.04
Net Return ($)	35.46	49.18	65.00	80.79	93.46	96.61	336.17
Grain Sorghum							
Yield (cwt)	70.00	73.95	78.36	82.76	86.29	87.17	147.95
Price ($/cwt)	4.05	4.05	4.05	4.05	4.05	4.05	4.05
Gross Return ($)	283.50	299.50	317.36	335.18	349.47	353.04	599.20
Production Cost ($)	257.11	262.75	268.64	274.54	279.25	280.43	345.53
Net Return ($)	26.39	36.75	48.72	60.64	70.22	72.61	253.67
Corn							
Yield (bu)	175.00	184.87	195.89	206.91	215.73	217.93	369.87
Price ($/bu)	2.48	2.48	2.48	2.48	2.48	2.48	2.48
Gross Return ($)	434.00	458.48	485.81	513.14	535.01	540.47	917.28
Production Cost ($)	316.00	322.93	330.17	337.42	343.21	344.66	424.67
Net Return ($)	118.00	135.55	155.64	175.72	191.80	195.81	492.61
Aquaculture							
Yield (lbs)	4,750.00	5,017.81	5,316.96	5,616.12	5,855.44	5,915.27	10,039.49
Price ($/lb)	0.79	0.79	0.79	0.79	0.79	0.79	0.79
Gross Return ($)	3,769.60	3,982.13	4,219.54	4,456.95	4,646.88	4,694.36	7,967.34
Production Cost ($)	2,780.46	2,841.46	2905.18	2968.90	3019.88	3,032.62	3736.68
Net Return ($)	989.14	1,140.67	1,314.36	1,488.05	1,627.00	1,661.74	4,230.66

Table D-III-6
Present (1995) and Projected Crop Yields, Gross Returns, Production Costs, and Net Returns per Acre
Dryland Crops, Without-Project Conditions
Grand Prairie Area Demonstration Project
(October 1995 Price Levels)

Item	Year						
	1995	2000	2005	2010	2014	2015	2063
Soybeans Single-Cropped							
Yield (bu)	22.00	23.24	24.63	26.01	27.12	27.40	46.50
Price ($/bu)	5.95	5.95	5.95	5.95	5.95	5.95	5.95
Gross Return ($)	130.90	138.28	146.55	154.76	161.36	163.03	276.68
Production Cost ($)	152.69	156.04	159.54	163.04	165.84	166.54	205.20
Net Return ($)	-21.79	-17.76	-12.99	-8.28	-4.48	-3.51	71.48
Soybeans Double-Cropped							
Wheat							
Yield (bu)	45.00	47.54	50.37	53.21	55.47	56.04	95.11
Price ($/bu)	3.04	3.04	3.04	3.04	3.04	3.04	3.04
Soybeans							
Yield (bu)	20.00	21.13	22.39	23.65	24.66	24.91	42.27
Price ($/bu)	5.95	5.95	5.95	5.95	5.95	5.95	5.95
Gross Return ($)	255.80	270.25	286.35	302.48	315.36	318.58	540.64
Production Cost ($)	285.94	292.21	298.76	305.32	310.56	311.87	384.28
Net Return ($)	-30.14	-21.96	-12.41	-2.84	4.80	6.71	156.36
Grain Sorghum							
Yield (cwt)	45.00	47.54	50.37	53.21	55.47	56.04	95.11
Price ($/cwt)	4.05	4.05	4.05	4.05	4.05	4.05	4.05
Gross Return ($)	182.25	192.54	204.00	215.50	224.65	226.96	385.20
Production Cost ($)	178.20	182.11	186.19	190.28	193.54	194.36	239.48
Net Return ($)	4.05	10.43	17.81	25.22	31.11	32.60	145.72
Corn							
Yield (bu)	85.00	89.79	95.14	100.50	104.78	105.85	179.65
Price ($/bu)	2.48	2.48	2.48	2.48	2.48	2.48	2.48
Gross Return ($)	210.80	222.68	235.95	249.24	259.85	262.51	445.53
Production Cost ($)	225.16	230.10	235.26	240.42	244.55	245.58	302.59
Net Return ($)	-14.36	-7.42	0.69	8.82	15.30	16.93	142.94

Table D-III-7
Present (1995) and Projected Net Revenues
Without-Project Conditions
Grand Prairie Area Demonstration Project
(October 1995 Price Levels, $000)

Item	Year						
	1995	2000	2005	2010	2014	2015	2063
Irrigated Crops							
Rice	10,090	6,801	6,099	5,215	4,379	4,152	11,308
Soybeans-Single	4,232	2,941	2,701	2,352	2,000	1,901	5,552
Soybeans Double-Cropped	2,233	1,774	1,781	1,653	1,463	1,403	4,953
Grain Sorghum	246	196	197	184	162	156	552
Corn	839	552	486	409	339	321	818
Total Irrigated Net Revenues	17,639	12,265	11,264	9,813	8,344	7,932	23,183
Dryland Crops							
Soybeans-Single	0	-1,402	-1,379	-1,075	-635	-499	10,386
Soybeans Double-Cropped	0	-591	-461	-152	214	325	7,727
Grain Sorghum	0	41	90	154	216	234	1,061
Corn	0	-23	0	39	81	93	796
Total Dryland Net Revenues	0	-1,974	-1,751	-1,034	-123	152	19,970
Aquaculture	3,067	2,026	1,789	1,509	1,255	1,188	3,063
Total	20,707	12,317	11,302	10,287	9,476	9,273	46,216

D-III-6. WITH-PROJECT CONDITIONS.

No project has been identified which provides all of the irrigation water needed all of the time. Alternative 3A provides a limited portion of the area's needs. However, Alternatives 5A and 6A consistently provide a majority of the area's water needs. Alternative 5A(6) is used for presentation purposes in this section. Major components of the project are increased conservation levels, additional on-farm storage reservoirs, and the import system bringing water from the White River with the withdrawal limitation of the Current State Water Plan.

a. Demand for Irrigation Water. The first step in implementing the project was to look at alternative ways to cut the demand for irrigation water. This had to be done since there was no source available that would provide for all of the area's projected unmet needs. NRCS studied the area's water usage and determined it to be at a 60% efficiency level. This means that of all the water drawn from the area's sources, only 60% actually gets to the fields and is used by the crops. They then developed additional conservation measures that could be applied to the area's farms to make them more efficient in their water use. The optimum conservation level was found to be 70% efficiency. Additional information on the selection of this level can be found in the NRCS Appendix of this report. This level of conservation was used in all of the alternatives presented in this section.

b. Supply of Irrigation Water. The supply model developed by the Memphis District in conjunction with HEC was run for each alternative for the period 1940 through 1986. Table D-III-8 shows that Alternative 5A(6) can provide an average of 265,500 additional acre-feet of water per year for a total of 387,900 acre-feet per year. This level will provide approximately 84.3% of an average year's irritagion need. Even with this project in place there will be an unmet need or shortage of 72,200 acre-feet which will mean a portion of the area's cropland will convert to dryland practices.

c. Acres of Each Crop. The shortage in available irrigation water directly translates into a reduction in irrigated acreage. By 2015 the acreage of irrigated crops is expected to be reduced to 227,800, a 14.8% reduction. Approximately 39,500 acres should be shifted to dryland farming practices. Soybeans will make up the majority (94%) of the dryland crops with 27,700 acres single cropped and 9,300 double cropped with wheat. The remainder will be comprised of grain sorghum at 1,400 acres and corn at 1,100. Irrigated crops would be composed of 82,700 acres of rice, 74,800 acres of single cropped soybeans, 53,700 acres of double cropped soybeans, 7,900 acres of grain sorghum, 6,100 acres of corn, and 2,600 acres of aquaculture. Projected with-project land use by crop is presented in Table D-III-9 for both irrigated and dryland crops.

Table D-III-8
Present (1995) and Projected Demand and Supply of Irrigation Water
Alternative 5A(6)
Current State Water Plan
Grand Prairie Area Demonstration Project
(Acre-Feet)

Item	Year						
	1995	2000	2005	2010	2014	2015	2063
Demand	536,900	536,900	513,270	483,734	460,104	460,104	460,104
Supply							
Project Features	0	0	0	132,800	255,700	265,500	265,500
Groundwater	417,200	174,700	129,300	84,000	47,700	38,600	38,600
Storage Reservoirs	69,500	69,500	69,500	69,500	69,500	69,500	69,500
Tailwater Recovery	50,200	25,200	21,600	17,900	15,000	14,300	14,300
Total	536,900	269,400	220,400	304,200	387,900	387,900	387,900
Shortfall	0	267,500	292,870	179,534	72,204	72,204	72,204

Table D-III-9

Present (1995) and Projected Land Use

Alternative 5A(6)

Grand Prairie Area Demonstration Project

(Acres)

	Year						
Item	1995	2000	2005	2010	2014	2015	2063
Irrigated Cropland							
Rice	97,100	55,600	47,000	64,800	82,700	82,700	82,700
Soybeans Single-Cropped	87,700	50,200	42,400	58,700	74,800	74,800	74,800
Soybeans Double-Cropped	63,000	36,100	30,500	42,100	53,700	53,700	53,700
Grain Sorghum	9,300	5,300	4,500	6,200	7,900	7,900	7,900
Corn	7,100	4,100	3,500	4,800	6,100	6,100	6,100
Aquaculture	3,100	1,800	1,500	2,000	2,600	2,600	2,600
Total	267,300	153,100	129,400	178,600	227,800	227,800	227,800
Dryland Cropland							
Soybeans Single-Cropped	0	80,300	96,700	62,200	27,700	27,700	27,700
Soybeans Double-Cropped	0	26,900	32,500	20,900	9,300	9,300	9,300
Grain Sorghum	0	4,000	4,900	3,100	1,400	1,400	1,400
Corn	0	3,000	3,800	2,500	1,100	1,100	1,100
Total	0	114,200	137,900	88,700	39,500	39,500	39,500
Total Cropland	267,300	267,300	267,300	267,300	267,300	267,300	267,300

d. Crop Data. The crop data per acre should be essentially the same as for existing conditions with one exception. There is expected to be as an added beneficial effect a reduction in the on-farm pumping cost of irrigation water. Presently approximately 85% of irrigation water comes from groundwater and 15% from surface water. With the project approximately 90% of the water will come from surface water and only 10% from groundwater. Surface water requires significantly lower energy and equipment costs to apply to the area's fields than does groundwater. The current (1995) production costs per acre and current and projected cost savings per acre are presented in Table D-III-10. All other data for the irrigated crops are presented in Table D-III-11. Dryland crop data per acre is the same as presented in Table D-III-6.

e. Net Revenue. By 2015 total net revenue or net farm income is expected to increase substantially over without-project conditions after completion of the project. Net farm income is expected to be $42.5 million versus $9.3 million without the project. Rice and soybeans are the major contributors to net farm income at $19.3 million and $16.7 million, respectively followed by aquaculture at $4.4 million. By the end of the project's economic life net farm income is expected to increase to $111.6 million. Net farm income under with-project conditions is presented in Table D-III-12 for the period 1995 through 2063.

D-III-7. BENEFITS.

All project benefits are based on current price levels, estimated over a 50-year project life plus the installation period, and discounted to the end of the project installation period using the current Federal discount rate. The project benefits consist of irrigation benefits, NED employment benefits, and waterfowl and fisheries benefits. Irrigation benefits consist of the difference between with- and without-project revenue streams. They are comprised of the value of the increased crop production due to maintaining irrigation versus dryland practices and any efficiencies or cost savings of using surface water instead of groundwater. NED Employment benefits consist of the project's labor component that goes to local under- or unemployed labor and will be estimated in accord with ER 1105-2-100. A detailed description of the waterfowl and fisheries benefits can be found in the Environmental Appendix of this report. The following sections present the methodologies used to calculate each of the benefit categories in this analysis.

Table D-III-10
Present (1995) and Projected Cost Savings per Acre
Irrigated Crops, Alternative 5A(6)
Grand Prairie Area Demonstration Project
(October 1995 Price Levels)

Item	1995 Cost Per Acre		Cost Savings Per Acre						
	Without-Project	With-Project	1995	2000	2005	2010	2014	2015	2063
	($)	($)	($)	($)	($)	($)	($)	($)	($)
Rice	145.43	96.50	48.93	49.74	50.95	52.15	53.12	53.36	65.75
Soybeans Single-Cropped	83.53	55.42	28.10	28.57	29.26	29.95	30.51	30.65	37.76
Soybeans Double-Cropped	81.88	54.32	27.56	28.02	28.70	29.38	29.92	30.06	37.03
Grain Sorghum	58.17	38.59	19.58	19.90	20.39	20.87	21.26	21.35	26.31
Corn	102.55	68.00	34.56	35.13	35.98	36.83	37.52	37.68	46.43
Composite Acre	105.50	70.00	35.50	36.09	36.96	37.84	38.54	38.71	47.70

Table D-III-11
Present (1995) and Projected Crop Yields, Gross Returns, Production Costs, and Net Returns per Acre
Irrigated Crops, Alternative 5A(6)
Grand Prairie Area Demonstration Project
(October 1995 Price Levels)

Item	Year						
	1995	2000	2005	2010	2014	2015	2063
Rice							
Yield (bu)	145.0	153.18	162.31	171.44	178.74	180.57	306.47
Price ($/cwt)	7.15	7.15	7.15	7.15	7.15	7.15	7.15
Gross Return ($)	466.54	492.86	522.23	551.61	575.10	580.98	986.07
Production Cost ($)	319.19	326.43	333.67	340.90	346.69	348.14	428.97
Net Return ($)	147.35	166.43	188.56	210.71	228.41	232.84	557.10
Soybeans Single-Cropped							
Yield (bu)	45.00	47.54	50.37	53.21	55.47	56.04	95.11
Price ($/bu)	5.95	5.95	5.95	5.95	5.95	5.95	5.95
Gross Return ($)	267.75	282.86	299.70	316.60	330.05	333.44	565.90
Production Cost ($)	194.56	198.97	203.38	207.79	211.32	212.20	261.47
Net Return ($)	73.19	83.89	96.32	108.81	118.73	121.24	304.43
Soybeans Double-Cropped							
Wheat							
Yield (bu)	45.00	47.54	50.37	53.21	55.47	56.04	95.11
Price ($/bu)	3.04	3.04	3.04	3.04	3.04	3.04	3.04
Soybeans							
Yield (bu)	40.00	42.26	44.78	47.29	49.31	49.81	84.55
Price ($/bu)	5.95	5.95	5.95	5.95	5.95	5.95	5.95
Gross Return ($)	374.80	395.97	419.57	443.13	462.02	466.73	792.21
Production Cost ($)	298.06	304.82	311.58	318.33	323.74	325.09	400.57
Net Return ($)	76.74	91.15	107.99	124.80	138.28	141.64	391.64
Grain Sorghum							
Yield (cwt)	70.00	73.95	78.36	82.76	86.29	87.17	147.95
Price ($/cwt)	4.05	4.05	4.05	4.05	4.05	4.05	4.05
Gross Return ($)	283.50	299.50	317.36	335.18	349.47	353.04	599.20
Production Cost ($)	239.80	245.24	250.68	256.11	260.46	261.55	322.27
Net Return ($)	43.70	54.26	66.68	79.07	89.01	91.49	276.93
Corn							
Yield (bu)	175.00	184.87	195.89	206.91	215.73	217.93	369.87
Price ($/bu)	2.48	2.48	2.48	2.48	2.48	2.48	2.48
Gross Return ($)	434.00	458.48	485.81	513.14	535.01	540.47	917.28
Production Cost ($)	285.53	292.00	298.48	304.95	310.13	311.42	383.72
Net Return ($)	148.47	166.48	187.33	208.19	224.88	229.05	533.56
Aquaculture							
Yield (lbs)	4,750.00	5,017.81	5,316.96	5,616.12	5,855.44	5,915.27	10,039.49
Price ($/lb)	0.79	0.79	0.79	0.79	0.79	0.79	0.79
Gross Return ($)	3,769.60	3,982.13	4,219.54	4,456.95	4,646.88	4,694.36	7,967.34
Production Cost ($)	2,780.46	2,841.46	2905.18	2968.90	3019.88	3,032.62	3736.68
Net Return ($)	989.14	1,140.67	1,314.36	1,488.05	1,627.00	1,661.74	4,230.66

Table D-III-12
Present (1995) and Projected Net Revenues
Irrigated Crops, Alternative 5A(6)
Grand Prairie Area Demonstration Project
(October 1995 Price Levels, $000)

Item	Year						
	1995	2000	2005	2010	2014	2015	2063
Irrigated Crops							
Rice	10,090	6,801	6,680	12,877	18,919	19,265	46,652
Soybeans-Single	4,232	2,941	3,081	6,004	8,885	9,063	23,040
Soybeans Double-Cropped	2,233	1,774	2,476	4,938	7,427	7,603	21,299
Grain Sorghum	246	196	226	462	706	726	2,228
Corn	839	552	486	932	1,364	1,388	3,272
Total Irrigated Net Revenues	17,639	12,265	12,949	25,213	37,301	38,044	96,491
Dryland Crops							
Soybeans-Single	0	-1,402	-1,565	-587	-123	-96	1,994
Soybeans Double-Cropped	0	-591	-524	-83	42	62	1,483
Grain Sorghum	0	41	102	84	42	45	204
Corn	0	-23	0	21	16	18	153
Total Dryland Net Revenues	0	-1,974	-1,987	-565	-24	29	3,833
Aquaculture	3,067	2,026	1,484	2,902	4,303	4,392	11,323
Total	20,707	12,317	12,446	27,551	41,580	42,466	111,647

a. Irrigation Benefits. Irrigation benefits were derived from maintaining as high a level of irrigation practices as possible and from lower irrigation costs due to reduced pumping costs as surface water is substituted for groundwater. Without the project, the aquifer is expected be depleted to such a point that a large portion of the presently irrigated crops will shift to dryland practices. As the groundwater available without the project declines, the irrigated acres will shift to dryland crops. With the project, import water is provided to replace the lost groundwater. This allows irrigation practices to continue to the level at which the import sources can sustain. Irrigation benefits are the difference in total net revenues between the with- and without-project conditions. Total revenues for Alternative 5A(6) and without-project conditions and project benefits during the project implementation period and by decade throughout the project life are presented in Table D-III-13. The benefits begin in 2002 as conservation measures and on-farm storage reservoirs are constructed. The majority of the benefits come from soybeans and rice with aquaculture and corn adding slightly to the totals. Average annual equivalent revenues and benefits are also presented in Table D-III-13. Benefits under traditional methods are estimated at $52.5 million annually while annual benefits under risk-based methods are estimated at $52.3 million.

(1). Risk Analysis. This section provides an estimate of the risk inherent with the data used to evaluate the effects of the project. It addresses the areas where risk and uncertainty are known to exist so that the economic performance of a project can be expressed in terms of probability distributions. This analysis was performed with Excel 5.0 spreadsheets in conjunction with version 3 of the add-on simulation model entitled @Risk. It incorporates the range (maximum and minimum) of possible values for an input variable, and specifies the statistical distribution of likely outcomes over the chosen range. In the case where a normal distribution is assumed, 68% percent of the occurrences of a particular outcome fall within (plus or minus) one standard deviation, on either side of the mean, and 95% percent within two standard deviations on either side of the mean. The initial step in constructing an @Risk simulation is to identify the sources of uncertainty. Some sources of risk and uncertainty arise from measurement errors, small sample sizes, estimation and forecasting errors, and modeling errors. The variables affecting the benefits, the shape of their distributions, and the amounts they are allowed to vary during the simulation are presented in Table D-III-14.

The @Risk simulation was performed utilizing 5,000 iterations, or different combinations, of the economic variables. The 68 and 95 percent confidence bands around the mean results are plus/minus one and two standard deviations, respectively. An additional step was taken to identify which variable(s) contributed the most to uncertainty. The simulation was run again, varying each variable individually while holding the remaining variables constant. The most important variable was the 25% variation in crop yield, followed by the 15% variation in crop prices and 2 standard deviations in existing water sources. The 2 standard deviations in the input projection factor, 10% variation in crop mix, and variation in interest rate had negligible effect on the annual benefits. If the analysis was conducted again these three factors should be held constant.

Table D-III-13
Present (1995) and Projected Irrigation Benefits
Alternative 5A(6)
Grand Prairie Area Demonstration Project
(October 1995 Price Levels, $000)

Year	With-Project	Without-Project	Benefit
1995	20,707	20,707	0
2000	12,317	12,317	0
2001	12,114	12,114	0
2002	12,155	11,911	244
2003	12,224	11,708	516
2004	12,321	11,505	816
2005	12,446	11,302	1,144
2006	12,599	11,099	1,500
2007	18,636	10,896	7,740
2008	20,365	10,693	9,672
2009	23,382	10,490	12,892
2010	27,551	10,287	17,264
2011	32,647	10,084	22,563
2012	34,848	9,881	24,967
2013	39,086	9,678	29,408
2014	41,580	9,476	32,104
2015	42,466	9,273	33,193
2024	55,172	16,058	39,114
2034	69,291	23,598	45,693
2044	83,410	31,137	52,273
2054	97,529	38,677	58,852
2064	111,647	46,216	65,431
Average Annual Equivalent Values @ 7.75% Discount Rate			
Traditional	86,214	33,683	52,531
Risk Based			
Mean	86,416	34,142	52,274
Standard Deviation	18,251	13,671	9,548

Table D-III-14

Results of Risk Analysis

Means and Standard Deviations of Average Annual Equivalent Irrigation Benefits Resulting from Varying Individual Risk-Based Items

Plus/Minus Two Standard Deviations

Alternative 5A(6), Grand Prairie Area Demonstration Project

(October 1995 Price Levels, $000)

Item	Annual Benefit		Distribution	Variation in Item
	Mean	Standard Deviation		
Crop Yields	52,536	7,892	Truncated Normal	25%
Crop Prices	52,531	3,636	Truncated Normal	15%
Without-Project Supply	52,531	3,041	Truncated Normal	2 Standard Deviations
Output Projection Factors	52,580	2,177	Truncated Normal	2 Standard Deviations
Demand for Irrigation Water	52,240	2,111	Truncated LogNormal	2 Standard Deviations
Production Cost	52,530	1,064	Truncated Normal	5%
Input Projection Factor	52,528	287	Truncated Normal	2 Standard Deviations
Crop Mix	52,530	253	Truncated Normal	10%
Interest Rate	52,537	231	Truncated Normal	Allows interest rate to range between 7.25% and 8.25%
All Items	52,274	9,548		

(2). Reliability Analysis. This section provides information on the reliability of the project in providing adequate water to irrigate the project area. There are two factors influencing the reliability of the project which are: (1) The demand for irrigation water and (2) The amount of water that the project can provide. The mean or average demand to irrigate the entire 267,300 acre project area is 460,100 acre-feet with a standard deviation of 73,400 acre-feet. The demand varied greatly over the 47 year period of record. It varied from a low of 335,000 acre-feet to a high of 666,200 acre-feet. The wide range between the two extremes is due to the unpredictability of rainfall and wide variation in temperatures from year to year. Lower rainfall and higher temperature levels usually increase the need for supplemental irrigation water. Higher rainfall and lower temperature levels usually decrease the need for supplemental irrigation water. The project is also limited to the amount of water that can be imported from the White River. This amount varies from year to year depending on the precipitation falling upstream of the import system. The mean demand met by Alternative 5A(6) is 387,900 acre-feet with a standard deviation of 91,700 acre-feet which translates into a mean irrigated acreage of 225,300 acres and a standard deviation of 53,200 acres. This means that on an average year approximately 84.3% of the project area can be fully irrigated.

Another way of looking at the reliability of the project in meeting irrigation demands is to see how often all of the area could be irrigated. Alternative 5A(6) could provide sufficient water to irrigate the entire 267,300 acre area 57.5% of the time or 27 years out of the 47 year period of record. This does not mean that for the remaining 42.5% of the time no irrigation would occur. Irrigation would always take place, just at lesser than maximum levels. Figures D-III-1 and D-III-2 graphically present the percent of an average year's irrigated acreage and the percent of time all of the area is irrigated based on the 47 year period of record. Table D-III-15 presents the above information for all alternatives.

(3). Summary of Irrigation Benefits. A summary of the irrigation benefits by alternative is presented in Table D-III-16. The benefits are presented for traditional methodology which is based on the average or best estimate and for risk-based results which are based on "Monte Carlo" simulation. Means and standard deviations are presented for the risk-based benefits

b. NED Employment Benefits. NED employment benefits reflect the economic impact on the project area as a result of construction and maintenance expenditures. When a county in the project area sustains persistent unemployment or under-employment, regulations allow the project benefits to be increased by the value of added area employment required for project construction and maintenance during the life of the project. The Grand Prairie project lies in Arkansas, Monroe, and Prairie Counties, Arkansas. Of these three, Monroe and Prairie are eligible for NED employment benefits due to unemployment problems. Approximately $134.9 million of the off-farm component of Alternative 5A(6)'s construction and relocation costs are expended in Monroe and Prairie Counties. Table D-III-17 depicts the process of allocating this cost to the employment of local labor. This procedure yields annual NED employment benefits of $1,811,000. The labor component of the operation, maintenance, and replacement of the off-farm component of the project in these two counties contributes an additional $257,000 annually to the project benefits. This component of the project benefits is presented in Table D-III-18.

Table D-III-15
Summary of Reliability Information
Grand Prairie Area Demonstration Project

Alternative	Mean Acres Irrigated (Acres)	Standard Deviation (Acres)	Percent of Mean Year's Irrigated Acreage	Percent of Time All of Area Irrigated (47 Year Record)
Alternative 3A	71,100	16,700	26.6%	0.0%
Alternative 5A(1)	266,500	41,200	99.7%	95.7%
Alternative 5A(2)	266,000	40,500	99.5%	91.5%
Alternative 5A(3)	260,900	39,600	97.6%	82.9%
Alternative 5A(4)	252,900	40,300	94.6%	74.5%
Alternative 5A(5)	242,700	43,600	90.8%	65.9%
Alternative 5A(6)	225,300	53,200	84.3%	57.5%
Alternative 5A(7)	213,600	53,000	79.9%	42.6%
Alternative 6A(1)	266,500	41,400	99.7%	97.0%
Alternative 6A(2)	266,200	40,700	99.6%	95.7%
Alternative 6A(3)	261,200	39,400	97.7%	80.9%
Alternative 6A(4)	253,400	40,200	94.8%	74.5%
Alternative 6A(5)	243,500	43,300	91.1%	65.9%
Alternative 6A(6)	225,900	55,100	84.5%	57.5%
Alternative 6A(7)	215,200	52,800	80.5%	46.8%

Figure D-III-1. Percent of Mean Year's Irrigated Crop Acreage Provided
Grand Prairie Demonstration Project
Alternatives 3A and 5A(1-7)

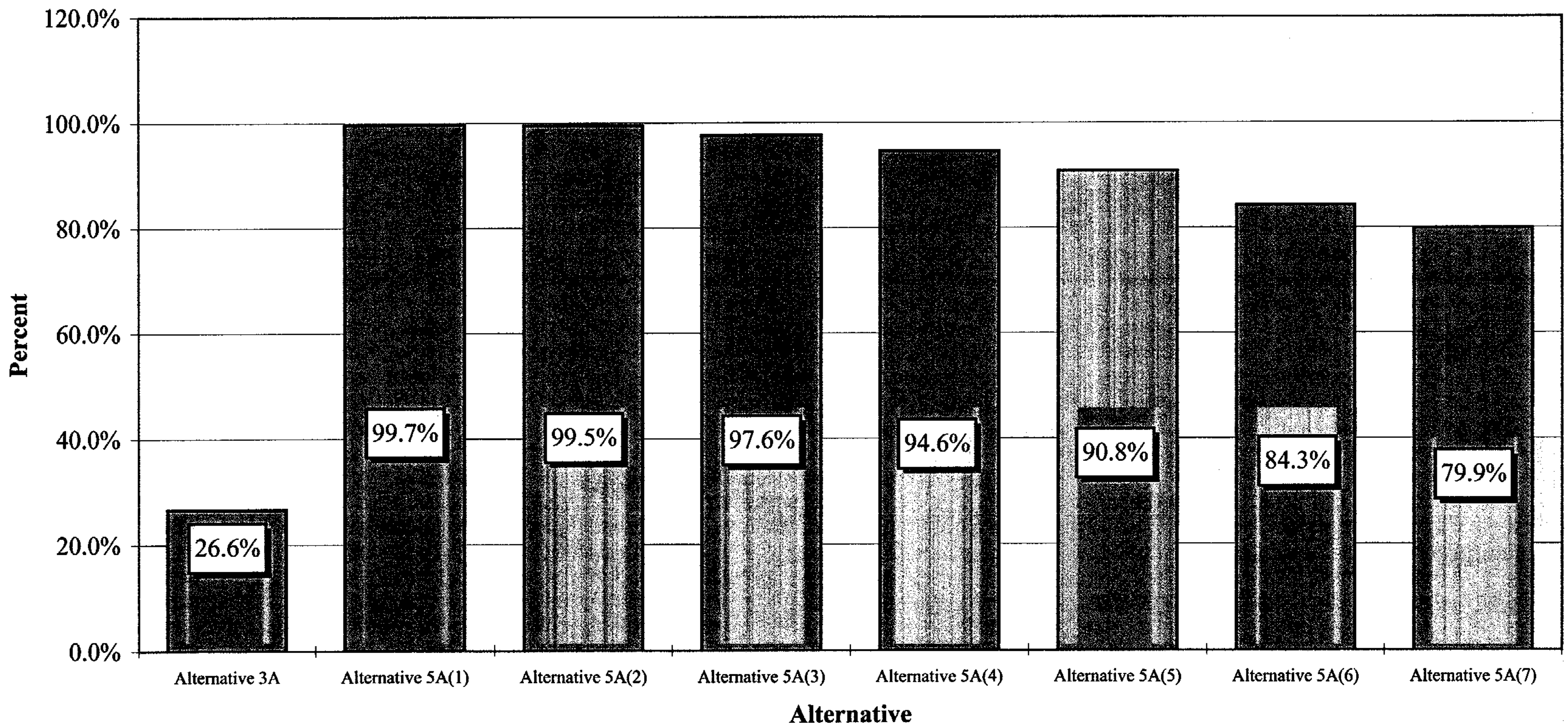

Figure D-III-2. Percent of Time All Cropland is Irrigated
Grand Prairie Demonstration Project
Alternative 3A and 5A(1-7)

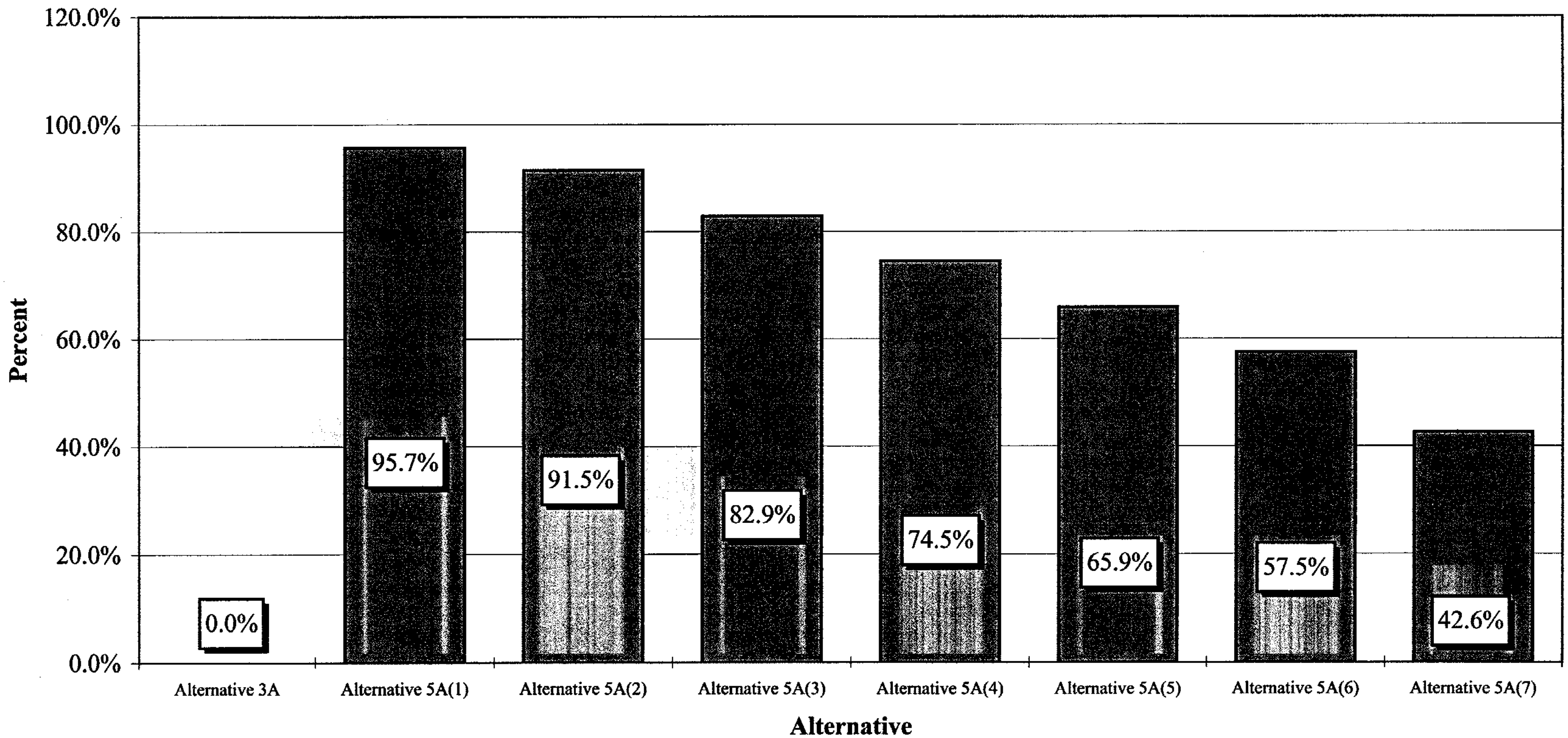

Table D-III-16

Summary of Annual Irrigation Benefits

Grand Prairie Area Demonstration Project

(October 1995 Price Levels, 7.75% Discount Rate)

Alternative	Traditional	Risk Based Mean	Risk Based Standard Deviation
	($000)	($000)	($000)
Alternative 3A	5,376	6,282	2,582
Alternative 5A(1)	64,318	64,070	11,520
Alternative 5A(2)	64,206	63,961	11,502
Alternative 5A(3)	62,695	62,458	11,244
Alternative 5A(4)	60,155	59,915	10,814
Alternative 5A(5)	56,862	56,620	10,262
Alternative 5A(6)	52,531	52,274	9,548
Alternative 5A(7)	47,398	47,147	8,721
Alternative 6A(1)	64,349	64,101	11,526
Alternative 6A(2)	64,248	64,003	11,509
Alternative 6A(3)	62,713	62,475	11,247
Alternative 6A(4)	60,227	59,987	10,826
Alternative 6A(5)	58,049	57,805	10,460
Alternative 6A(6)	52,448	52,201	9,534
Alternative 6A(7)	47,768	47,517	8,780

Table D-III-17

NED Employment Benefits

Alternative 5A(6)

Grand Prairie Demonstration Project

(October 1995 Price Levels, 7.75% Discount Rate)

1. Present Value of Expenditure:

FY	N	First Cost Relocations	First Cost Construction	PV Factor @ 7.75%	PV First Cost Relocations	PV First Cost Construction
2002	11	$ 3,164,000	$ 4,495,000	2.27295	$ 7,191,614	$ 10,216,910
2003	10	481,344	16,854,000	2.10947	1,015,381	35,553,007
2004	9	512,000	19,360,360	1.95774	1,002,363	37,902,551
2005	8	1,743,000	20,229,360	1.81693	3,166,909	36,755,331
2006	7	2,073,248	33,757,360	1.68625	3,496,014	56,923,348
2007	6	571,648	11,585,771	1.56496	894,606	18,131,268
2008	5	151,788	13,026,969	1.45240	220,457	18,920,370
2009	4	0	6,114,632	1.34794	0	8,242,157
2010	3	0	828,996	1.25098	0	1,037,057
2011	2	0	0	1.16101	0	0
2012	1		0	1.07750	0	0
2013	0		0	1.00000	0	0
		$8,697,028	$126,252,448		$16,987,344	$223,681,999

2. Estimated Labor by Unemployment Class:

Skilled			
Relocation	$ 16,987,344	0.155	$ 2,633,038
Construction	223,681,999	0.100	22,368,200
			$25,001,238
Semi- & Unskilled			
Relocation	$ 16,987,344	0.140	$ 2,378,228
Construction	223,681,999	0.135	30,197,070
			32,575,298

3. Allocation of Wages to Unemployed or Underemployed Labor:

Skilled	$25,001,238	0.30	$7,500,371
Semi- & Unskilled	32,575,298	0.47	15,310,390
			$22,810,761

4. Annual NED Employment Benefit:

Annual NED Employment Benefit	$22,810,761	0.07940	$1,811,000

Table D-III-18

NED Employment Benefits Accruing to Project Maintenance

Alternative 5A(6)

Grand Prairie Demonstration Project

(October 1995 Price Levels, 7.75% Discount Rate)

1. Labor Expenditures Over Project Life:

	Actual Wages		Present Value
Wages Paid Directly to Labor	$31,230,016		$10,504,212
Labor Component of Maintenance Items	4,684,916		947,181

2. Estimated Labor by Unemployment Class:

	Present Value		Skilled or Un-Skilled
Skilled			
Wages Paid Directly to Labor	$10,504,212		$10,504,212
Labor Component of Maintenance Items	947,181	0.100	94,718
			$10,598,930
Semi- & Unskilled			
Labor Component of Maintenance Items	947,181	0.135	127,869
			127,869

3. Allocation of Wages to Unemployed or Underemployed Labor:

	Skilled or Un-Skilled		Allocation
Skilled	$10,598,930	0.30	$3,179,679
Semi- & Unskilled	127,869	0.47	60,098
			$3,239,777

4. Annual NED Employment Benefit:	$3,239,777	0.07940	$ 257,000

The on-farm component of the project contributes an additional $1,825,000 to the project benefits. A detailed description of these benefits and the procedure used to estimate them is presented in the NRCS portion of this report. A summary of these benefits for all alternatives is presented in Table D-III-19.

c. Fish and Wildlife Benefits. Fish and wildlife benefits accrue to the project from several sources. The primary source of these benefits is the preparation and flooding of 45,000 acres of rice fields for winter waterfowl use. Other benefits accrue to on-farm storage ponds that will be built providing suitable habitat for wildlife and fisheries. Weirs in the irrigation canals will pool a significant amount of water which will provide habitat value. The project should also keep the area's farmers from pumping the existing streams dry as is happening under without-project conditions. A detailed description of these benefits and their computations is presented in the Environmental Appendix. Table D-III-20 presents the estimated benefits by year and annual benefits for waterfowl and fisheries for Alternative 5A(6). Table D-III-21 presents a summary of the annual waterfowl and fisheries benefits by alternative.

d. Total Annual Benefits. Total annual benefits accruing to Alternative 5A(6) are estimated at $54,838,000. Irrigation benefits account for $49,783,000 (91%) of the project benefits. The NED employment accounts for $3,893,000 (7%). Fish and wildlife benefits comprise the remaining $862,000 (2%). A summary of the annual benefits for all alternatives is presented in Table D-III-22.

D-III-8. COSTS.

The project costs like the annual benefits are based on current price levels, estimated over a 50-year project life plus the installation period, and discounted to the end of the project installation period using the current Federal discount rate. The annual costs consist of interest, sinking fund, operation, maintenance, and replacement charges. Also included in the annual costs are negative effects on navigation on the White River and potential induced flooding effects on existing streams in the project area which are used to convey irrigation flows.

a. First Costs. Total project costs for the off-farm component of Alternative 5A(6) are presented in Table D-III-23. They total $239,678,500 and include $10,000,000 in sunk PED costs. The largest part of the cost is the cost associated with the canals which account for approximately 55% of the off-farm cost. This cost includes the excavation of the canals plus the structures necessary to carry the water underneath existing roads and streams where necessary. The remaining off-farm costs are for the pump station, relocations, water control structures, lands, engineering and design, and supervision and administration. Total project costs for the on-farm component of Alternative 5A(6) are $75,900,000 (Table D-III-24). The largest component of these costs is for the storage reservoirs which accounts for approximately 45% of the on-farm cost. The remaining on-farm costs are for pipelines, pumps, water control structures, tailwater recovery system, and technical assistance. All costs are based on October 1995 price levels and are assumed to be end of year expenditures.

Table D-III-19

NED Employment Benefits

Grand Prairie Area Demonstration Project

(October 1995 Price Levels, 7.75% Discount Rate, $000)

Alternative	On-Farm	Import System	Total Benefit
Alternative 3A	573		573
Alternative 5A(1)	1,825	2,068	3,893
Alternative 5A(2)	1,825	2,068	3,893
Alternative 5A(3)	1,825	2,068	3,893
Alternative 5A(4)	1,825	2,068	3,893
Alternative 5A(5)	1,825	2,068	3,893
Alternative 5A(6)	1,825	2,068	3,893
Alternative 5A(7)	1,825	2,068	3,893
Alternative 6A(1)	2,129	2,068	4,197
Alternative 6A(2)	2,129	2,068	4,197
Alternative 6A(3)	2,129	2,068	4,197
Alternative 6A(4)	2,129	2,068	4,197
Alternative 6A(5)	2,129	2,068	4,197
Alternative 6A(6)	2,129	2,068	4,197
Alternative 6A(7)	2,129	2,068	4,197

Table D-III-20
Average Annual Equivalent Waterfowl and Fisheries Benefits
Alternative 5A(6)
Grand Prairie Area Demonstration Project
(October 1995 Price Levels, 7.75% Discount Rate)

Year	Waterfowl	Fisheries	Total
	($)	($)	($)
2007	173,860	18,623	192,483
2008	207,999	22,280	230,279
2009	265,938	28,486	294,424
2010	342,154	36,650	378,804
2011	430,305	46,092	476,397
2012	458,851	49,150	508,001
2013	521,476	55,858	577,334
2014	550,016	58,915	608,931
2015	550,016	58,915	608,931
2024	550,016	58,915	608,931
2034	550,016	58,915	608,931
2044	550,016	58,915	608,931
2054	550,016	58,915	608,931
2064	550,016	58,915	608,931
Average Annual Equivalent Values @ 7.75% Discount Rate			
	778,600	83,400	862,000

Table D-III-21

Average Annual Equivalent Waterfowl and Fisheries Benefits

Grand Prairie Area Demonstration Project

(October 1995 Price Levels, 7.75% Discount Rate)

Alternative	Waterfowl	Fisheries	Total Benefit
	($)	($)	($)
Alternative 3A	0	0	0
Alternative 5A(1)	902,700	83,300	986,000
Alternative 5A(2)	895,700	83,300	979,000
Alternative 5A(3)	827,600	83,400	911,000
Alternative 5A(4)	807,700	83,300	891,000
Alternative 5A(5)	742,600	83,400	826,000
Alternative 5A(6)	778,600	83,400	862,000
Alternative 5A(7)	591,700	83,300	675,000
Alternative 6A(1)	902,700	83,300	986,000
Alternative 6A(2)	895,700	83,300	979,000
Alternative 6A(3)	827,600	83,400	911,000
Alternative 6A(4)	810,700	83,300	894,000
Alternative 6A(5)	748,700	83,300	832,000
Alternative 6A(6)	784,700	83,300	868,000
Alternative 6A(7)	598,600	83,400	682,000

Table D-III-22

Summary of Average Annual Equivalent Benefits

Grand Prairie Area Demonstration Project

(October 1995 Price Levels, 7.75% Discount Rate, $000)

Alternative	Irrigation	Employment	Fish & Wildlife	Total
Alternative 3A	5,376	573	0	5,949
Alternative 5A(1)	61,569	3,893	986	66,448
Alternative 5A(2)	61,460	3,893	979	66,332
Alternative 5A(3)	59,956	3,893	911	64,760
Alternative 5A(4)	57,413	3,893	891	62,197
Alternative 5A(5)	54,119	3,893	826	58,838
Alternative 5A(6)	49,783	3,893	862	54,538
Alternative 5A(7)	44,645	3,893	675	49,213
Alternative 6A(1)	61,599	4,197	986	66,782
Alternative 6A(2)	61,503	4,197	979	66,679
Alternative 6A(3)	59,973	4,197	911	65,081
Alternative 6A(4)	57,485	4,197	894	62,576
Alternative 6A(5)	55,305	4,197	832	60,334
Alternative 6A(6)	49,699	4,197	868	54,764
Alternative 6A(7)	45,015	4,197	682	49,894

Table D-III-23

Cost Schedule for Off-Farm Component of Project (Import System and Pumping Station)

Alternative 5A(6)

Grand Prairie Area Demonstration Project

(October 1995 Price Levels)

FY	Lands	Relocations	Canals	Pump Station	Structures	E&D	S&A	Sub-Total LERRD	Sub-Total Construction	Total First Cost
2000						10,000,000 1/		0	10,000,000	10,000,000
2001	225,000					2,298,000		225,000	2,298,000	2,523,000
2002	1,047,600	3,164,000		4,495,000		2,607,000	360,000	4,211,600	7,462,000	11,673,600
2003	689,600	552,000	6,543,000	10,113,000	198,000	374,000	1,186,000	1,241,600	18,414,000	19,655,600
2004	356,400	512,000	9,548,000	10,000,000	197,000	615,000	1,345,000	868,400	21,705,000	22,573,400
2005	672,600	1,743,000	11,273,000	6,000,000	3,341,000	970,000	1,600,000	2,415,600	23,184,000	25,599,600
2006	675,900	2,144,000	19,900,000	10,113,000	4,129,000	814,000	2,159,000	2,819,900	37,115,000	39,934,900
2007	724,000	812,000	7,613,000	4,224,000		1,220,000	452,000	1,536,000	13,509,000	15,045,000
2008	735,000	1,092,000	16,292,000		790,000	866,000	903,333	1,827,000	18,851,333	20,678,333
2009	1,077,500	1,004,000	18,170,000		448,000	1,639,000	986,667	2,081,500	21,243,667	23,325,167
2010	840,300	1,260,000	27,284,000			388,000	1,440,000	2,100,300	29,112,000	31,212,300
2011	465,700	497,000	3,960,000			142,000	219,000	962,700	4,321,000	5,283,700
2012	13,000	0	7,494,000				421,000	13,000	7,915,000	7,928,000
2013	66,900	0	3,960,000				219,000	66,900	4,179,000	4,245,900
	7,589,500	12,780,000	132,037,000	44,945,000	9,103,000	21,933,000	11,291,000	20,369,500	219,309,000	239,678,500

1/ Sunk PED cost.

Table D-III-24

Cost Schedule for On-Farm Component of Project

Alternative 5A(6)

Grand Prairie Area Demonstration Project

(October 1995 Price Levels)

FY	Storage Reservoirs	On-Farm Pipelines	Tailwater Recovery	On-Farm Pumps	Water Control Structures	Sub-Total First Cost	Technical Assistance	Total First Cost
2001	2,631,700	1,443,600	186,600	599,000	216,000	5,076,900	761,500	5,838,400
2002	2,631,800	1,443,500	186,600	599,000	216,000	5,076,900	761,600	5,838,500
2003	2,631,700	1,443,600	186,600	599,000	216,000	5,076,900	761,600	5,838,500
2004	2,631,800	1,443,500	186,600	599,000	216,000	5,076,900	761,500	5,838,400
2005	2,631,700	1,443,600	186,600	599,000	216,000	5,076,900	761,600	5,838,500
2006	2,631,800	1,443,500	186,600	599,000	216,100	5,077,000	761,500	5,838,500
2007	2,631,700	1,443,600	186,600	599,000	216,000	5,076,900	761,500	5,838,400
2008	2,631,800	1,443,500	186,600	599,000	216,100	5,077,000	761,500	5,838,500
2009	2,631,700	1,443,500	186,600	599,000	216,100	5,076,900	761,600	5,838,500
2010	2,631,800	1,443,500	186,600	599,000	216,000	5,076,900	761,500	5,838,400
2011	2,631,800	1,443,500	186,600	598,900	216,100	5,076,900	761,600	5,838,500
2012	2,631,800	1,443,500	186,600	599,000	216,100	5,077,000	761,500	5,838,500
2013	2,631,800	1,443,500	186,600	598,900	216,100	5,076,900	761,500	5,838,400
	34,212,900	18,765,900	2,425,800	7,786,800	2,808,600	66,000,000	9,900,000	75,900,000

b. Annual Interest and Sinking Fund Costs. The annual interest and sinking fund costs for both the off-farm and the on-farm components of Alternative 5A(6) are presented in Table D-III-25. All annual costs are based on a reference point at the end of year 2013, the current discount rate of 7.75 percent, and a 50 year period of analysis. Annual interest charges are approximately \$38.6 million. Annual sinking fund charges are slightly less than \$1 million.

c. Annual Operation and Maintenance Costs. The annual operation, maintenance, and replacement costs for the off-farm component of Alternative 5A(6) are presented in Table D-III-26. The annual costs for the on-farm component are presented in Table D-III-27. They are also use the end of 2013 as the reference point for discounting, a discount rate of 7.75 percent, and a 50 year period of analysis. Annual costs are \$4,953,000 and \$1,315,000 for the off-farm and on-farm components respectively. Approximately 84% of the off-farm operation and maintenance costs are for energy followed by labor at 14% and maintenance and replacements at slightly over 2%. On-farm annual costs are comprised of maintenance to the reservoirs (43%), pumps (24%), pipelines (23%), tailwater recovery (6%), and water control structures (4%).

d. Induced Crop Damage. Induced flooding effects have been quantified using traditional methodologies used for Corps flood control projects. These methodologies include the use of partial duration stage frequency curves, stage area curves, area frequency curves, and the CACFDAS program. All potential flood effects are agricultural. Only minor (almost insignificant) effects on Mill Bayou and Little Lagrue Bayou have been identified. Since the increases are only between 2 and 4 tenths of a foot, minor modifications might be made to off set these increases. Also, the operation plan may be developed in such a way as to stop the additional flows during rainy periods, alleviating any potential increases in flooding. However, for this analysis, worst case scenarios were assumed in that nothing would be done to offset the potential increases. The potential increase in flood damage for Mill Bayou is approximately \$8,000 annually. The potential increase in damage for Little Lagrue Bayou is approximately \$4,000 annually. Total annual increases are \$12,000 (Table D-III-28) which compares to only 0.022 percent of project annual benefits.

e. Effects on Navigation. This section analyzes the impacts of 7 residual flow or stop-pump levels in the White River. Each residual flow level is a minimum stream flow at which diversions from the White River will be suspended until the stop-pump flow level is exceeded. Again, the residual flow levels investigated are: 5,250 cfs, 7,125 cfs, 9,650 cfs, 11,350 cfs, 12,850 cfs, 17,500 cfs, and the variable level called for in the Arkansas State Water Plan (SWP).

Table D-III-25

Average Annual Equivalent Interest and Sinking Fund Costs

Alternative 5A(6)

Grand Prairie Area Demonstration Project

(October 1995 Price Levels, 7.75% Discount Rate)

FY	Off-Farm Cost	On-Farm Cost	Total Cost	Present Value Factor @ 7.75%	Present Value Cost
2000	10,000,000		10,000,000 1/	2.638910	
2001	2,523,000	5,838,400	8,361,400	2.449100	20,477,905
2002	11,673,600	5,838,500	17,512,100	2.272950	39,804,128
2003	19,655,600	5,838,500	25,494,100	2.109470	53,779,039
2004	22,573,400	5,838,400	28,411,800	1.957740	55,622,917
2005	25,599,600	5,838,500	31,438,100	1.816930	57,120,827
2006	39,934,900	5,838,500	45,773,400	1.686250	77,185,396
2007	15,045,000	5,838,400	20,883,400	1.564960	32,681,686
2008	20,678,333	5,838,500	26,516,833	1.452400	38,513,048
2009	23,325,167	5,838,500	29,163,667	1.347940	39,310,873
2010	31,212,300	5,838,400	37,050,700	1.250980	46,349,685
2011	5,283,700	5,838,500	11,122,200	1.161010	12,912,985
2012	7,928,000	5,838,500	13,766,500	1.077500	14,833,404
2013	4,245,900	5,838,400	10,084,300	1.000000	10,084,300
	239,678,500	75,900,000	315,578,500		498,676,193
	Interest			0.07750	38,647,000
	Sinking Fund (50 Year Life)			0.00190	948,000
	Total				39,595,000

1/ Sunk PED Cost.

Table D-III-26

Average Annual Equivalent Off-Farm Operation, Maintenance, and Replacement Costs

Alternative 5A(6)

Grand Prairie Area Demonstration Project

(October 1995 Price Levels, 7.75% Discount Rate)

Fiscal Year	Number of Years Discounted	Large Pumping Station	Small Pumping Stations	Structures	Canals	Total	Present Value Factor @ 7.75%	Present Value of Total
2007	-6	1,002,194	141,700	61,012	0	1,204,906	1.56496	1,885,629
2008	-5	1,002,194	141,700	61,012	0	1,204,906	1.45240	1,750,005
2009	-4	1,268,836	188,933	81,349	0	1,539,118	1.34794	2,074,638
2010	-3	1,535,478	236,166	101,687	62,048	1,935,378	1.25098	2,421,119
2011	-2	1,802,119	283,399	122,024	0	2,207,543	1.16101	2,562,978
2012	-1	2,068,761	330,632	142,361	0	2,541,755	1.07750	2,738,741
2013	0	2,468,724	401,482	172,868	138,399	3,181,472	1.00000	3,181,473
2014	1	2,868,686	472,332	203,374	0	3,544,392	0.92807	3,289,444
2015	2	2,868,686	472,332	203,374	0	3,544,392	0.86132	3,052,855
2016	3	2,868,686	472,332	203,374	163,933	3,708,325	0.79937	2,964,324
2017	4	2,868,686	472,332	203,374	0	3,544,392	0.74188	2,629,514
2018	5	2,868,686	472,332	203,374	0	3,544,392	0.68852	2,440,385
2019	6	2,868,686	472,332	203,374	163,933	3,708,325	0.63899	2,369,583
2020	7	2,868,686	472,332	203,374	0	3,544,392	0.59303	2,101,931
2021	8	2,868,686	472,332	203,374	0	3,544,392	0.55038	1,950,763
2022	9	2,868,686	472,332	203,374	163,933	3,708,325	0.51079	1,894,174
2023	10	2,868,686	472,332	203,374	0	3,544,392	0.47405	1,680,219
2024	11	2,868,686	472,332	203,374	0	3,544,392	0.43996	1,559,390
2025	12	2,868,686	472,332	203,374	163,933	3,708,325	0.40831	1,514,145
2026	13	2,868,686	472,332	203,374	165,461	3,709,853	0.37894	1,405,811
2027	14	3,243,686	473,870	204,297	0	3,921,853	0.35169	1,379,276
2028	15	2,868,686	475,409	205,220	210,961	3,760,276	0.32639	1,227,316
2029	16	2,868,686	476,947	206,143	50,577	3,602,353	0.30292	1,091,225
2030	17	2,868,686	478,486	207,066	105,998	3,660,236	0.28113	1,029,002
2031	18	2,868,686	480,024	207,989	163,933	3,720,632	0.26091	970,750
2032	19	2,868,686	481,563	208,912	20,945	3,580,106	0.24214	866,886
2033	20	2,868,686	483,101	209,835	47,147	3,608,770	0.22473	810,998
2034	21	2,868,686	484,640	210,758	163,933	3,728,017	0.20856	777,516
2035	22	2,868,686	486,178	211,681	0	3,566,546	0.19356	690,341
2036	23	2,868,686	487,717	212,604	0	3,569,007	0.17964	641,137
2037	24	2,868,686	489,255	213,527	163,933	3,735,402	0.16672	622,765
2038	25	2,868,686	490,794	214,450	0	3,573,930	0.15473	552,995
2039	26	2,868,686	492,332	215,374	0	3,576,392	0.14360	513,570
2040	27	2,868,686	492,332	215,374	163,933	3,740,325	0.13327	498,472
2041	28	2,868,686	492,332	215,374	0	3,576,392	0.12368	442,328
2042	29	3,249,474	492,332	215,374	0	3,957,180	0.11479	454,244
2043	30	2,868,686	492,332	215,374	163,933	3,740,325	0.10653	398,457
2044	31	2,868,686	492,332	215,374	0	3,576,392	0.09887	353,597
2045	32	2,868,686	492,332	215,374	0	3,576,392	0.09176	328,169
2046	33	2,868,686	492,332	215,374	329,394	3,905,786	0.08516	332,617
2047	34	3,383,686	492,332	215,374	0	4,091,392	0.07903	323,342
2048	35	2,868,686	492,332	215,374	47,028	3,623,420	0.07335	265,778
2049	36	2,868,686	492,332	215,374	214,510	3,790,902	0.06807	258,047
2050	37	2,868,686	492,332	215,374	105,998	3,682,390	0.06318	232,653
2051	38	2,868,686	492,332	215,374	0	3,576,392	0.05863	209,685
2052	39	2,868,686	492,332	215,374	184,878	3,761,270	0.05442	204,687
2053	40	2,868,686	492,332	215,374	47,147	3,623,539	0.05050	182,989
2054	41	2,868,686	492,332	215,374	0	3,576,392	0.04687	167,624
2055	42	2,868,686	492,332	215,374	163,933	3,740,325	0.04350	162,704
2056	43	2,868,686	492,332	215,374	0	3,576,392	0.04037	144,378
2057	44	2,868,686	492,332	215,374	0	3,576,392	0.03747	134,007
2058	45	2,868,686	492,332	215,374	163,933	3,740,325	0.03477	130,050
2059	46	2,868,686	492,332	215,374	0	3,576,392	0.03227	115,409
2060	47	2,868,686	492,332	215,374	0	3,576,392	0.02995	107,112
2061	48	2,868,686	492,332	215,374	163,933	3,740,325	0.02780	103,981
2062	49	2,868,686	492,332	215,374	0	3,576,392	0.02580	92,272
2063	50	2,868,686	492,332	215,374	0	3,576,392	0.02394	85,619
		155,853,405	25,960,613	11,282,992	3,697,687	196,794,697		62,369,119
Total Annual Cost (50 Year Life)							0.07940	4,953,000

Table D-III-27

Average Annual Equivalent On-Farm Operation, Maintenance, and Replacement Costs

Alternative 5A(6)

Grand Prairie Area Demonstration Project

(October 1995 Price Levels, 7.75% Discount Rate)

Fiscal Year	Number of Years Discounted	Irrigation Pipe	Pumps and Power Units	Water Control Structures	Reservoirs	Tail Water Recovery	Total	Present Value Factor @ 7.75%	Present Value of Total
2001	-12	0	0	0	0	0	0	2.44910	0
2002	-11	14,435	14,975	2,161	26,318	3,732	61,621	2.27295	140,062
2003	-10	28,871	29,950	4,322	52,635	7,465	123,242	2.10947	259,976
2004	-9	43,306	44,925	6,482	78,953	11,197	184,863	1.95774	361,915
2005	-8	57,742	59,900	8,643	105,271	14,929	246,485	1.81693	447,845
2006	-7	72,177	74,875	10,804	131,588	18,662	308,106	1.68625	519,543
2007	-6	86,612	89,850	12,965	157,906	22,394	369,727	1.56496	578,608
2008	-5	101,048	104,825	15,125	184,224	26,126	431,348	1.45240	626,490
2009	-4	115,483	119,800	17,286	210,542	29,858	492,969	1.34794	664,493
2010	-3	129,918	134,775	19,447	236,859	33,591	554,590	1.25098	693,781
2011	-2	144,354	149,750	21,608	263,177	37,323	616,212	1.16101	715,428
2012	-1	158,789	164,725	23,768	289,495	41,055	677,833	1.07750	730,365
2013	0	173,225	179,700	25,929	315,812	44,788	739,454	1.00000	739,454
2014	1	187,660	194,675	28,090	342,130	48,520	801,075	0.92807	743,454
2015	2	187,660	194,675	28,090	342,130	48,520	801,075	0.86132	689,982
2016	3	187,660	194,675	28,090	342,130	48,520	801,075	0.79937	640,355
2017	4	187,660	194,675	28,090	342,130	48,520	801,075	0.74188	594,302
2018	5	187,660	194,675	28,090	342,130	48,520	801,075	0.68852	551,556
2019	6	187,660	194,675	28,090	342,130	48,520	801,075	0.63899	511,879
2020	7	187,660	194,675	28,090	342,130	48,520	801,075	0.59303	475,062
2021	8	187,660	194,675	28,090	342,130	48,520	801,075	0.55038	440,896
2022	9	187,660	194,675	28,090	342,130	48,520	801,075	0.51079	409,181
2023	10	187,660	194,675	28,090	342,130	48,520	801,075	0.47405	379,750
2024	11	187,660	194,675	28,090	342,130	48,520	801,075	0.43996	352,441
2025	12	187,660	194,675	28,090	342,130	48,520	801,075	0.40831	327,087
2026	13	187,660	194,675	28,090	342,130	48,520	801,075	0.37894	303,559
2027	14	187,660	194,675	28,090	342,130	48,520	801,075	0.35169	281,730
2028	15	187,660	194,675	28,090	342,130	48,520	801,075	0.32639	261,463
2029	16	187,660	194,675	28,090	342,130	48,520	801,075	0.30292	242,662
2030	17	187,660	194,675	28,090	342,130	48,520	801,075	0.28113	225,206
2031	18	187,660	194,675	28,090	342,130	48,520	801,075	0.26091	209,008
2032	19	187,660	194,675	28,090	342,130	48,520	801,075	0.24214	193,972
2033	20	187,660	194,675	28,090	342,130	48,520	801,075	0.22473	180,026
2034	21	187,660	194,675	28,090	342,130	48,520	801,075	0.20856	167,072
2035	22	187,660	194,675	28,090	342,130	48,520	801,075	0.19356	155,056
2036	23	187,660	194,675	28,090	342,130	48,520	801,075	0.17964	143,905
2037	24	187,660	194,675	28,090	342,130	48,520	801,075	0.16672	133,555
2038	25	187,660	194,675	28,090	342,130	48,520	801,075	0.15473	123,950
2039	26	187,660	194,675	28,090	342,130	48,520	801,075	0.14360	115,034
2040	27	187,660	194,675	28,090	342,130	48,520	801,075	0.13327	106,759
2041	28	187,660	194,675	28,090	342,130	48,520	801,075	0.12368	99,077
2042	29	187,660	194,675	28,090	342,130	48,520	801,075	0.11479	91,955
2043	30	187,660	194,675	28,090	342,130	48,520	801,075	0.10653	85,339
2044	31	187,660	194,675	28,090	342,130	48,520	801,075	0.09887	79,202
2045	32	187,660	194,675	28,090	342,130	48,520	801,075	0.09176	73,507
2046	33	187,660	194,675	28,090	342,130	48,520	801,075	0.08516	68,220
2047	34	187,660	194,675	28,090	342,130	48,520	801,075	0.07903	63,309
2048	35	187,660	194,675	28,090	342,130	48,520	801,075	0.07335	58,759
2049	36	187,660	194,675	28,090	342,130	48,520	801,075	0.06807	54,529
2050	37	187,660	194,675	28,090	342,130	48,520	801,075	0.06318	50,612
2051	38	187,660	194,675	28,090	342,130	48,520	801,075	0.05863	46,967
2052	39	187,660	194,675	28,090	342,130	48,520	801,075	0.05442	43,595
2053	40	187,660	194,675	28,090	342,130	48,520	801,075	0.05050	40,454
2054	41	187,660	194,675	28,090	342,130	48,520	801,075	0.04687	37,546
2055	42	187,660	194,675	28,090	342,130	48,520	801,075	0.04350	34,847
2056	43	187,660	194,675	28,090	342,130	48,520	801,075	0.04037	32,339
2057	44	187,660	194,675	28,090	342,130	48,520	801,075	0.03747	30,016
2058	45	187,660	194,675	28,090	342,130	48,520	801,075	0.03477	27,853
2059	46	187,660	194,675	28,090	342,130	48,520	801,075	0.03227	25,851
2060	47	187,660	194,675	28,090	342,130	48,520	801,075	0.02995	23,992
2061	48	187,660	194,675	28,090	342,130	48,520	801,075	0.02780	22,270
2062	49	187,660	194,675	28,090	342,130	48,520	801,075	0.02580	20,668
2063	50	187,660	194,675	28,090	342,130	48,520	801,075	0.02394	19,178
		10,508,960	10,901,800	1,573,040	19,159,280	2,717,120	44,860,200		16,566,946
Total Annual Cost (50 Year Life)								0.07940	1,315,000

Table D-III-28

Average Annual Equivalent Induced Crop Damage

All Plans of Improvement

Grand Prairie Area Demonstration Project

(October 1995 Price Levels, 7.75% Discount Rate)

Item	Little Lagure Bayou	Mill Bayou
1. Expected Annual Acres		
With-Project	1,037	2,088
Without-Project	957	1,915
Increase	80	173
2. Damage Rate/Acre	$ 46.22	$ 46.22
3. Annual Damage		
With-Project	$ 48,000	$ 97,000
Without-Project	44,000	89,000
Increase	4,000	8,000

(1). Present Movements. The desired monthly movements under present day or 1995 conditions was estimated using the most recent information available from the USACE Waterborne Commerce Statistics Center (1982 through 1993). Periods of very low movements due to droughts or floods were excluded as were periods of extremely high movements which seemed to be periods of catch-up after periods of low movements. These periods would tend to bias the time of year the movements would occur. As would be expected, the results indicate that the desired shipments out of the White River system are highest during and immediately following soybean and wheat harvest. Receipts coming into the White River system are relatively constant throughout the year. Additionally, only tonnage moving out of or into the White River system was considered in this analysis. All movements between ports on the White River effectively occurred at or upstream of DeValls Bluff, Arkansas. Since the Grand Prairie Demonstration Project will only affect the White River at and below DeValls Bluff, tonnage moving between White River ports but not out of or into the system was excluded.

Movements for 1995 were estimated at 550,000 tons which were comprised of 80,000 tons of receipts and 470,000 tons of shipments. The 80,000 tons in receipts consisted of 59,000 tons of fertilizer and fertilizer materials (74%) and 21,000 tons of waterway improvement materials and sand and gravel (26%). The 470,000 of shipments included 285,000 tons of soybeans (61%), 160,000 tons of wheat (34%), and 24,000 tons of grain sorghum (5%). Monthly receipts and shipments are shown in Table D-III-29.

(2). Future Movements. The production of agricultural commodities and the use of agricultural production inputs in the area are expected to increase over time as new technologies, crop varieties, and production practices are developed and adopted by area farmers. A description of the methodology used in projecting future production and future use of production inputs is presented in the benefit segment of this section. Since the majority of the movements on the White River are agricultural crops or production items (96.2%), these movements should also be expected to experience an increase. The only commodity not projected to increase is the receipt of waterway improvement materials, which is held constant. Waterway improvement materials are used solely for maintenance on the White River and thus should not change significantly baring any large scale changes to the existing river channel. The increase in barged tonnage is assumed to be proportional to the other transportation modes. All movements of each transportation mode (truck, rail, and barge) are expected to grow at the same rate.

Future movements are presented in Table D-III-29. Movements are projected to increase 21.8% to 670,000 tons by 2015 and to 1,103,000 tons by 2064. The shipments of soybeans, wheat, and grain sorghum are projected to increase proportionally thus keeping the percentage of each constant at 61%, 34%, and 5%, respectively. Receipts of waterway improvement materials are held constant at 21,000 tons with all increases in receipts coming from fertilizer and fertilizer materials. Again, tonnage not leaving the White River system is excluded from these movements for the rationale given for present movements.

Table D-III-29

Desired Monthly Receipts and Shipments

Present and Projections for Future Conditions

White River, Arkansas

Grand Prairie Area Demonstration Project

(tons)

Month	1995			2015			2064		
	Receipts	Shipments	Total	Receipts	Shipments	Total	Receipts	Shipments	Total
January	7,700	88,800	96,500	8,200	110,500	118,700	9,700	189,300	199,000
February	7,200	99,700	106,900	7,700	124,000	131,700	9,100	212,400	221,500
March	8,500	65,500	74,000	9,000	81,500	90,500	10,700	139,600	150,300
April	7,100	29,600	36,700	7,500	36,800	44,300	8,900	63,000	71,900
May	8,700	11,100	19,800	9,200	13,800	23,000	10,900	23,600	34,500
June	18,900	53,400	72,300	20,200	66,500	86,700	24,000	113,900	137,900
July	8,200	40,300	48,500	8,700	50,200	58,900	10,300	86,000	96,300
August	3,300	9,200	12,500	3,500	11,500	15,000	4,200	19,700	23,900
September	500	3,100	3,600	500	3,900	4,400	800	6,700	7,500
October	2,000	4,000	6,000	2,100	5,000	7,100	2,500	8,600	11,100
November	1,700	14,000	15,700	1,800	17,400	19,200	2,100	29,800	31,900
December	6,200	51,300	57,500	6,600	63,900	70,500	7,800	109,400	117,200
Total	80,000	470,000	550,000	85,000	585,000	670,000	101,000	1,002,000	1,103,000

(3). Water Depths. The economic optimization of the irrigation project is to be determined by analyzing an array of residual flow or stop-pump levels. Therefore, it is important to be able to relate river flows to water depths in the navigation channel. An ongoing dredging program causes the relationship between water depth and river flow to vary somewhat throughout the year. Immediately prior to dredging a higher flow is required to obtain a navigable depth. Immediately after dredging a lower flow is required for a navigable depth. To compensate for this problem, an average of pre- and post-dredge conditions was used to relate flows versus water depths. A 47 year period of record (1940-1986) of these average weekly water depths was developed for without- and with-project conditions and used to evaluate the effects of water depths on present and projected movements .

In conjunction with the above, the following four assumptions comprise the basis of the analysis of water depths. These assumptions apply to both without- and with-project conditions.

- An 8 foot average weekly depth is required for a light loaded barge to move on the White River. No movements would occur with less than an 8 foot average weekly depth.
- Fully loaded barges were assumed to move at 9 foot and greater average depths.
- River flows of 17,500 cfs and above cause no hindrances to navigation,
- River flows of 9,650 cfs and below would halt navigation completely.

(4). Assumptions Influencing Impacts to Tonnage. The desired monthly movement schedule presented in Table D-III-29 was compared to the 47 year period of record of average weekly water depths for both without- and with-project conditions to determine the effects on tonnage. But before this was done, three assumptions were made which apply to both without- and with-project conditions:

- Soybeans received during the fall and early winter were desired to be moved by the end of May. Any stocks remaining due to unfavorable without- or with-project river conditions would be moved by an alternate mode.
- Wheat received during the late spring and early summer was desired to be moved by the end of September. Any stocks remaining due to unfavorable without- or with-project river conditions would be moved by an alternate mode.
- For present (1995) conditions, no more than the historical maximum movement could take place for any one time period. (Example: March's historical maximum movement was 160,000 tons. Therefore, no more than 160,000 tons could be moved during March). These maximums were allowed to grow proportionately over time along with the expected increase in movements since any significant increase in tonnage would require a corresponding increase in the capacity of the local barge industry.

(5). Without-Project Impacts to Movements. The results of the comparison indicate that navigation is being significantly impaired by low water depths during present day or existing conditions. The desired monthly schedule presented in Table D-III-29 could be met without any problems only 2 years (4.3% of time) out of the 47 year period of record. Light loading of some movements would occur during 6 years (12.8% of time) without delays or diversions. During an additional 23 years (48.9% of time) there would be delays of movements along with light loading. For the remaining 16 years (34.0% of time) there would be diversions along with delays and light loading.

Annual movements affected by existing river flows are presented in Table D-III-30 for present (1995) conditions along with projections for 2015 and 2064. The movements presented are receipts and shipments combined and are for light loading, diversions, and delays. Delays are defined as a delay of one ton for one month (i.e., delay of two tons could be two tons delayed for one month each or one ton delayed for two months). Existing river conditions cause light loadings of 33,872 tons, diversions of 32,215 tons and, delays of 228,619 tons. These problems are expected to increase as the area's agricultural production increases. Future without-project light loading of barges will increase to 41,274 tons and 83,222 tons in 2015 and 2064, respectively. Diversions to other modes will grow to 39,359 tons in 2015 and 79,922 tons in 2064. Delays are expected to grow to 278,576 tons in 2015 and 561,725 tons in 2064.

(6). With-Project Impacts to Movements. At the 9,650 level there would be no effect on movements during 18 years (38.3% of time) of the 47 year period of record. During 5 years (10.6% of time) there would be additional light loading. Additional delays would occur during 6 years (12.8% of time). For the remaining 18 years (38.3% of time) there would be diversions along with delays and light loading. The Arkansas State Water Plan (SWP) would have no effect for 31 years or 66.0% of the time. There would be 5 years (10.6% of time) of additional light loading along with 3 additional years (6.4% of time) of delays and an additional 8 years (17.0% of time) of added diversions, delays, and light loading.

Annual movements affected by the various residual flow levels are also presented in Table D-III-30 for present (1995) conditions along with projections for 2015 and 2064. The movements are also receipts and shipments combined. The 9,650 cfs alternative is estimated to cause annual light loading of 45,772 tons, diversions of 50,339 tons, and delays of 270,742 tons per year under the 1995 level of movements. As agricultural production in the area grows, annual impacts are projected to grow to 55,774 tons of light loadings, 61,502 tons of diversions, and 329,904 tons of delays in 2015. Projected annual figures for 2064 are 112,459 tons of light loadings, 124,886 tons of diversions, and 665,223 tons of delays. The SWP is expected to cause annual light loading of 39,772 tons, diversions of 39,015 tons, and delays of 241,319 tons for 1995. Annual impacts for the SWP are projected to grow to 48,454 tons of light loadings, 47,667 tons of diversions, and 294,051 of delays in 2015. A annual figures for 2064 are 97,651 tons of light loadings, 96,798 tons of diversions, and 592,928 tons in delays.

Table D-III-30

Annual Tonnage Affected by Low River Flows

Without- and With-Project

Present and Projections for Future Conditions

White River, Arkansas

Grand Prairie Area Demonstration Project

(tons)

Condition	1995			2015			2064		
	Delayed 1/	Diverted	Light Loaded	Delayed 1/	Diverted	Light Loaded	Delayed 1/	Diverted	Light Loaded
Without-Project	228,619	32,215	33,872	278,576	39,359	41,274	561,725	79,922	83,222
Alternative 5A(3)	270,742	50,339	45,772	329,904	61,502	55,774	665,223	124,886	112,459
Alternative 5A(4)	260,999	46,147	43,020	318,032	56,380	52,420	641,284	114,486	105,697
Alternative 5A(5)	252,403	42,448	40,592	307,557	51,861	49,461	620,162	105,310	99,730
Alternative 5A(6)	241,319	39,015	39,772	294,051	47,667	48,454	592,928	96,798	97,651
Alternative 5A(7)	228,619	32,215	33,872	278,576	39,359	41,274	561,725	79,922	83,222

1/ Denotes tonnage that is delayed one month (i.e. one ton-month). One ton delayed for one month is counted as one ton. One ton delayed for two months is counted as two tons. One ton delayed for three months is counted as three tons, etc.

The incremental differences (difference between without- and with project) are presented in Table D-III-31. Using the present (1995) effects of the SWP as an example, of the 39,772 tons in light loadings, only 5,900 tons or 14.8% were caused by the plan. Similarly, only 6,800 tons of the 39,015 tons in diversions or 17.4% were caused by the plan. Only 12,700 tons of the 241,319 tons of delays or only 5.3% were caused by the project. Comparable results are also presented for the other plans and for projected (2015 and 2064) conditions.

(7). Monetary Impacts.

(a). Light Loading. The additional cost per ton due to light loading is the cost of shipping an 8 foot draft barge versus a 9 foot barge. The cost per ton of an 8 foot draft on the White River is estimated at $7.17 per ton. The cost per ton of a 9 foot draft is $6.58 per ton yielding a difference of $0.59 per ton. Applying this figure to the data for the 9,650 cfs alternative in Table D-III-31 yields added annual shipping costs due to light loading of $7,100 for 1995 conditions, $8,500 for 2015 conditions, and $17,200 for 2064 conditions (Table VI-C-32). The SWP's annual effects are significantly smaller at $3,500 for 1995, $4,300 for 2015, and $8,500 for 2064.

(b). Diversions. The added cost per ton due to diversions is the added cost of shipping the diverted tonnage by the next least costly means of transportation. In this case the least costly alternative is through an alternate port on a nearby waterway. The closest alternate ports available for the White River are located at Pine Bluff, Arkansas which is on the Arkansas River and Osceola, Arkansas and Memphis, Tennessee which are located on the Mississippi River. The tonnage on the lower White would be expected to go through Pine Bluff, Arkansas. The tonnage from the middle of the White system would be expected to go through Memphis, Tennessee. Osceola, Arkansas would probably move the diversions from the upper White River. The average cost of shipping through these ports is estimated to be $15.13 per ton which is comprised of $5.29 per ton in actual barge rates, $5.27 in trucking costs to the alternate port, and $4.57 in additional handling and shrinkage. The average cost of shipping on the White River is $6.58 which yields an increase of $8.55 per ton ($15.13-$6.58). Added annual costs due to diversions for the 9,650 cfs alternative are estimated at $155,000 for 1995 conditions, $189,300 for 2015 conditions, and $384,500 for 2064 conditions (Table D-III-32). The SWP would cause an estimated annual effect of $58,100 for 1995 conditions, $71,000 for 2015 conditions, and $144,200 for 2064 conditions.

Table D-III-31

Annual Tonnage Affected by Project

Incremental Difference Between Without- and With-Project

Present and Projections for Future Conditions

White River, Arkansas

Grand Prairie Area Demonstration Project

(tons)

Alternative	1995			2015			2064		
	Delayed 1/	Diverted	Light Loaded	Delayed 1/	Diverted	Light Loaded	Delayed 1/	Diverted	Light Loaded
Alternative 5A(3)	42,123	18,124	11,900	51,328	22,143	14,500	103,498	44,964	29,237
Alternative 5A(4)	32,380	13,932	9,148	39,456	17,022	11,146	79,559	34,564	22,475
Alternative 5A(5)	23,784	10,233	6,719	28,981	12,503	8,187	58,437	25,388	16,508
Alternative 5A(6)	12,700	6,800	5,900	15,475	8,308	7,188	31,204	16,871	14,486
Alternative 5A(7)	0	0	0	0	0	0	0	0	0

1/ Denotes tonnage that is delayed one month (i.e. one ton-month). One ton delayed for one month is counted as one ton. One ton delayed for two months is counted as two tons. One ton delayed for three months is counted as three tons, etc.

Table D-III-32

Annual Impacts to Navigation by Project

Present and Projections for Future Conditions

White River, Arkansas

Grand Prairie Area Demonstration Project

(October 1995 Price Levels)

Alternative	1995				2015				2064			
	Delayed 1/	Diverted	Light Loaded	Total	Delayed 1/	Diverted	Light Loaded	Total	Delayed 1/	Diverted	Light Loaded	Total
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Alternative 5A(3)	50,300	155,000	7,100	212,400	61,100	189,300	8,500	258,900	121,600	384,500	17,200	523,300
Alternative 5A(4)	38,700	119,100	5,400	163,200	47,000	145,500	6,600	199,100	93,500	295,500	13,300	402,300
Alternative 5A(5)	28,400	87,500	4,000	119,900	34,500	106,900	4,800	146,200	68,600	217,100	9,700	295,400
Alternative 5A(6)	15,200	58,100	3,500	76,800	18,400	71,000	4,300	93,700	36,700	144,200	8,500	189,400
Alternative 5A(7)	0	0	0	0	0	0	0	0	0	0	0	0

1/ Denotes tonnage that is delayed one month (i.e. one ton-month). One ton delayed for one month is counted as one ton. One ton delayed for two months is counted as two tons. One ton delayed for three months is counted as three tons, etc.

(c). Delays. The loss caused by delays is estimated as the interest associated with not being able to sell the delayed commodities on a timely basis and use the proceeds to either invest or to pay off obligations. The interest rate used in this section is the current Federal discount rate of 7.75 percent. The monthly delay cost for receipts is estimated at $1.45 per ton ($225/ton of fertilizer times 7.75% divided by 12 months). The monthly delay cost for shipments is estimated to be $1.15 per ton (average of $220/ton for soybeans and $135/ton for wheat times 7.75% divided by 12 months). An average of soybean and wheat values was used for shipments. Although soybeans account for almost twice the shipments as wheat (61% versus 34%) the window of opportunity for shipping soybeans is about twice as long (December through March versus June through July) and soybeans are shipped during historically higher river levels. These values can be applied directly to the ton-months of delays presented in Table D-III-31. Added annual costs due to delays for the 9,650 cfs alternative are estimated at $50,300 for 1995 conditions, $61,100 for 2015 conditions, and $121,600 for 2064 conditions (Table D-III-32). The SWP would cause an estimated annual effect of $15,200 for 1995 conditions, $18,400 for 2015 conditions, and $36,700 for 2064 conditions.

(8). Summary of Effects to Navigation. The estimated revenue generated by shipping on the White River is $3,619,000 (550,000 tons from Table D-III-29 times $6.58 shipping cost/ton). The 9,650 cfs residual flow level causes negative effects of $420,000 (Table D-III-33) or 11.6% of current revenues. The SWP would cause losses of $152,000 or 4.2% of current revenues. If all of these losses were passed on to users of the waterway, the resulting annual increase per ton would be $0.76 for the 9,650 cfs residual flow level and $0.28 for the SWP. Diversions would be 18,124 tons (3.3% of current movements) and 6,800 tons (1.2% of current movements) for the 9,650 cfs level and SWP, respectively.

f. Total Annual Costs. Total project first costs for Alternative 5A(6) are $315,578,500. Federal costs account for $205,126,000 with Non-Federal costs making up the remaining $110,452,500. Annual interest charges are $38,647,000 and annual sinking fund charges are $948,000 (Table D-III-34). The project also requires annual operation and maintenance of $6,268,000 and causes annual induced impacts to navigation of $318,000 and annual crop damages of $12,000. Total annual costs for Alternative 5A(6) are estimated at $46,552,000.

D-III-9. ECONOMIC JUSTIFICATION.

Table D-III-35 shows that Alternative 5A(6) is economically justified since its annual benefits exceed annual costs by $8,511,000 and its benefit to cost ratio is 1.18 to 1. All other plans are also economically justified. Alternative 3A has the highest benefit-to-cost ratio but returns fewer excess benefits. All of Alternative 5A's plans return higher benefits but lower excess benefits than Alternative 6A.

Table D-III-33
Average Annual Equivalent Impacts to Navigation
White River, Arkansas
Grand Prairie Area Demonstration Project
(October 1995 Price Levels, 7.75% Discount Rate, 50 Year Project Life)

Residual River Flow	Alternative 5A	Alternative 5B
5,250	420,000	420,000
7,125	420,000	420,000
9,650	420,000	420,000
11,350	420,000	420,000
12,850	318,000	318,000
SWP	152,000	152,000
17,500	0	0

Table D-III-34

Summary of Average Annual Equivalent Costs

Grand Prairie Area Demonstration Project

(October 1995 Price Levels, 7.75% Discount Rate, $000)

Alternative	Interest	Sinking Fund	Operation, Maintenance, and Replacement	Induced Crop Damage	Navigation Impacts	Total
Alternative 3A	2,546	63	350	0	0	2,959
Alternative 5A(1)	38,647	948	7,334	12	420	47,361
Alternative 5A(2)	38,647	948	7,322	12	420	47,349
Alternative 5A(3)	38,647	948	7,182	12	420	47,209
Alternative 5A(4)	38,647	948	6,973	12	420	47,000
Alternative 5A(5)	38,647	948	6,705	12	318	46,630
Alternative 5A(6)	38,647	948	6,268	12	152	46,027
Alternative 5A(7)	38,647	948	5,945	12	0	45,552
Alternative 6A(1)	40,243	987	7,501	12	420	49,163
Alternative 6A(2)	40,243	987	7,489	12	420	49,151
Alternative 6A(3)	40,243	987	7,349	12	420	49,011
Alternative 6A(4)	40,243	987	7,144	12	420	48,806
Alternative 6A(5)	40,243	987	6,885	12	318	48,445
Alternative 6A(6)	40,243	987	6,455	12	152	47,849
Alternative 6A(7)	40,243	987	6,139	12	0	47,381

Table D-III-35

Summary of First Costs and Average Annual Equivalent Benefits, Costs, Excess Benefits, and Benefit to Cost Ratios

Grand Prairie Area Demonstration Project

(October 1995 Price Levels, 7.75% Discount Rate, $000)

Alternative	Investment Cost	Annual Benefits	Annual Costs	Excess Benefits	Benefit to Cost Ratios
Alternative 3A	20,189	5,949	2,959	2,990	2.01
Alternative 5A(1)	315,579	66,448	47,361	19,087	1.40
Alternative 5A(2)	315,579	66,332	47,349	18,983	1.40
Alternative 5A(3)	315,579	64,760	47,209	17,551	1.37
Alternative 5A(4)	315,579	62,197	47,000	15,197	1.32
Alternative 5A(5)	315,579	58,838	46,630	12,208	1.26
Alternative 5A(6)	315,579	54,538	46,027	8,511	1.18
Alternative 5A(7)	315,579	49,213	45,552	3,661	1.08
Alternative 6A(1)	327,123	66,782	49,163	17,619	1.36
Alternative 6A(2)	327,123	66,679	49,151	17,528	1.36
Alternative 6A(3)	327,123	65,081	49,011	16,070	1.33
Alternative 6A(4)	327,123	62,576	48,806	13,770	1.28
Alternative 6A(5)	327,123	60,334	48,445	11,889	1.25
Alternative 6A(6)	327,123	54,764	47,849	6,915	1.14
Alternative 6A(7)	327,123	49,894	47,381	2,513	1.05

D-III-10. SUMMARY.

A summary of the economic analysis of all alternatives is presented in Table D-III-35. This table shows project first costs; average annual equivalent benefits, costs, and excess benefits over costs; and benefit to cost ratios for the three alternatives carried into detailed analysis. As previously stated, the conservation only alternative provides the best return per dollar invested. The optimum conservation efficiency (70%) was established by the NRCS. The documentation of this level as the optimum conservation level is presented in the NRCS's Appendix of this report. Also presented in Table D-III-35 are the two on-farm storage levels which were carried into further economic analysis. The smallest of these two levels (Alternative 5A) is the optimum storage level. Intuitively, it appears that a smaller level might be the optimum on-farm storage level. However, smaller levels reduce the conservation efficiencies developed by the NRCS. This is also documented in their appendix of this report. Since conservation returns the most per dollar invested, anything that reduces the conservation level moves the system away from economic optimization. Therefore, Alternative 5A is the optimum storage level. Seven levels of "stop-pump" or residual river flows in the White River are also presented. As shown in the table, the more water that can be withdrawn from the White River, the better the returns. However, the institutional constraint of the Arkansas State law on withdrawals limits the amount of water that the project can provide. Therefore, the State Water Plan is the withdrawal limitation chosen to carry into detailed study for the optimization of the pumping station and main canals along with the selected conservation and storage levels.

D-III-11. SUMMARY OF OPTIMIZATION OF INDIVIDUAL FEATURES.

Optimization of the individual project features was accomplished by analyzing an array of alternatives and operating plans. Two levels of on-farm storage reservoirs were investigated along with one pumping station and seven levels regulating White River withdrawals. Optimization of each component of the selected plan (Alternative 5A(6)) is presented in the following paragraphs.

a. Conservation Level. The recommended conservation level (Alternative 3A) yields a higher dollar return for each dollar invested than any of the other project features. It should always be used to the maximum or optimum extent before using any of the other features. Water provided by conservation is more cost effective than water provided by alternative sources. However, conservation cannot supply all of the Grand Prairie area's future without project unmet need. The limiting factor in using conservation measures is that they are effective only when there is available water to conserve or "stretch". A point is quickly reached where the available sources of irrigation water are exhausted. Although the existing sources have been "stretched" to the optimum extent, only a small portion of an average year's unmet need can be satisfied. Conservation practices should be used over the entire project area in conjunction with alternative sources since conservation reduces the total amount of water required and it is more cost efficient than alternative sources. Therefore, conservation should always be used as the first measure incorporated into a project design and be used until it is no longer cost efficient.

Conservation is used as a project feature until the level where its incremental benefit is outweighed by its incremental cost. Beyond this level additional measures are not economically justified. The NRCS has conducted exhaustive studies within the Grand Prairie project area to determine the optimum level. The NRCS began by determining the existing level of conservation measures which was found to be 60 %. This means that 60% of the water put on the fields was actually available for use by the crops. The other 40% was lost to evaporation, infiltration into the ground, and waste or spillage. The NRCS then determined the optimum with-project level which was found to be 70%. The NRCS's documentation for identifying the optimum level is found in its appendix of this report.

b. <u>On-Farm Storage Reservoirs</u>. This measure was optimized by analyzing four levels of on-farm storage. The first level was analyzed without alternative sources of irrigation water (Alternative 2). The other three levels of storage were analyzed in conjunction with an 1,800 CFS pumping station and import system (Alternatives 4A, 5A, and 6A). Alternatives 2 and 4A were evaluated from a physical standpoint only. They were not carried into detailed economic analysis. Only Alternatives 5A and 6A were carried into detailed economic analysis. Each is discussed in the following paragraphs

Alternative 2 is the amount of additional on-farm storage that could be filled using existing sources of surface water. Preliminary studies by NRCS had indicated that there was the potential for building approximately 1,400 surface acres of additional storage. Further modeling by the Memphis District indicated that irrigation water available to the farms might actually decrease if more reservoirs are built. This modeling showed that the area farmers are already catching the maximum amount of rainfall physically possible. Building more reservoirs would increase evaporation and infiltration losses as the water is spread over more surface acreage. Since it is questionable whether the reservoirs could be filled without an import system and since this alternative does not meet the objectives of the study, it was not carried forward into detailed study.

Alternative 4A used only the existing level of on-farm storage (no additional storage) in conjunction with the import system. After consultation with NRCS it was determined that the desired conservation efficiencies outlined above could not be achieved without building new reservoirs. Since all previous studies (Corps feasibility study and preliminary PED study and NRCS studies) have shown that conservation yields the most return for the dollar invested, this alternative was eliminated before going into detailed study. Any economic contributions made by it would be more than offset by the economic losses associated with the lost conservation efficiencies.

Alternative 5A is the minimum level of on-farm storage reservoirs necessary to achieve the 70% conservation levels outlined in previous sections. Any decrease would reduce the conservation efficiencies and cause a corresponding shift from irrigation to dryland practices during an average year. It calls for the construction of 9,790 surface acres off new reservoirs which would provide approximately 97,900 acre-feet of irrigation water. This volume will satisfy approximately 25 percent of existing irrigation needs or about 30 percent of with-project needs which are reduced by conservation measures. Any cost savings from reducing on-farm storage below this level would be more than offset by the economic losses associated with the lost conservation efficiencies. Because of this, lesser storage levels were not considered for detailed study. This minimum level was established by the NRCS and is documented in the NRCS Appendix in this report.

Alternative 6A called for increasing the on-farm storage reservoirs in Alternative 5A by 25% for an additional 2,448 surface acres or a total of 12,238 additional reservoirs. The economic evaluation presented in prior sections, shows that additional on-farm storage reservoirs, greater than the minimum required to achieve the with-project conservation level, are not economically justified.

The selected level of additional on-farm storage is 9,790 surface acres, supplying 97,900 acre-feet of irrigation water. This level is recommended based on supply-demand modeling as well as from an economic tradeoff analysis. Any movement either up or down will reduce the net economic benefits. Movement to lesser storage cuts benefits greater than costs while movement to larger levels adds to costs more than to benefits as shown in Table D-III-35.

c. Import System.

(1). Sizing. Presently, only an 1,800 CFS import system has been carried into detailed analysis. The import system size has not been optimized from an economic standpoint. The only economic analysis conducted has been to ensure that the import system is economically justified. However, the import system has been optimized based on its ability to meet an average year's unmet demand. The 1,800 CFS system is the minimum size necessary to meet an average year's unmet needs with unconstrained withdrawals of average year flows in the White River. An array of import system sizes will be explored during further study to identify the NED size.

(2). Operation/Withdrawal Limitations. The previous section outlining the economic tradeoffs of operating methods (withdrawal limitations) shows that the plan that allows the most withdrawals from the White River is the NED operating method as shown in Table D-III-35. However, current Arkansas State law prohibits implementation of most of these withdrawal schemes. Arkansas State law sets the maximum limit for withdrawals. This is an institutional or legal limit that cannot be changed without a change in current Arkansas state law. Because of the current law, the operating plan that limits withdrawals to the Arkansas State Water Plan is recommended for use with the selected operating plan. Operating plans that further increase withdrawal limitations (or reduce withdrawals) over the Arkansas State Water Plan, reduce the project benefits greater than any reductions of potential adverse effects or costs and as such are be recommended for adoption.

d. Summary. Each project feature has been optimized based the project's capability to supply an average year's unmet demand. All project features are at the minimum levels required to accomplish this function. Only the conservation measures and on-farm storage reservoirs have been optimized based on both supplying unmet demands and economic tradeoffs. Since their optimum levels have been established no further study is required to support their selection. These levels will be used in the economic optimization of the import system. Since the import system was optimized based only on supplying unmet needs, further economic optimization is needed to identify the NED import system size. The optimum operation plan of the import system from meeting demands and economic tradeoffs is the one which allows maximum withdrawals from the White

River which is not possible under Arkansas state law. Because of the current law, no further study of White River withdrawal limits will be conducted. Future optimization studies will focus on identifying the optimum import system size from an economic perspective while holding constant the current recommendations on conservation efficiencies, storage reservoirs, and White River withdrawal limits.